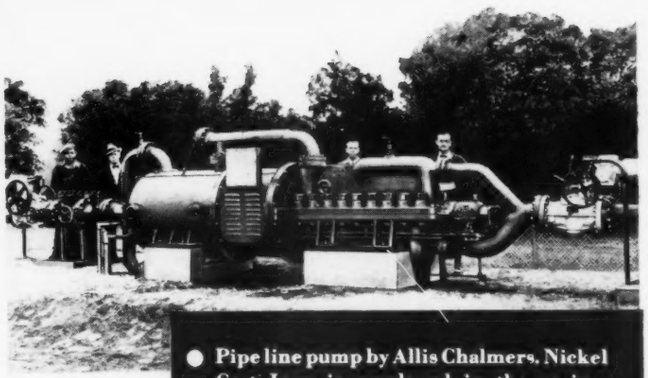
# Product Engineering

"COST CLOUDS"
have a bright side
when you use

# NICKEL
## CAST IRON

● Big reducers of operating costs, these Nickel Chromium Cast Iron cylinder liners. General Motors Truck Corp., now using them on new engines, reports they reduce cylinder reconditioning one-third and permit the use of the same cylinder blocks throughout their lives.

**FREE** Send for our handy celluloid vest pocket size "Hardness Conversion Table." Quickly gives approximate relation between Brinell, Rockwell and Shore hardness values and corresponding strengths of Nickel Alloy Steels. Address Dept. K5. The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.



● Pipe line pump by Allis Chalmers. Nickel Cast Iron is employed in the casing, wearing rings and bushings for improved strength, toughness and density.

● Winton Diesel—power plant of Burlington's stainless steel "Zephyr." Cylinder liners, cylinder heads and valve guides are made of hard, wear-resisting Nickel Cast Iron.

**THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.**

✦ PRODUCT ENGINEERING

# PRODUCT ENGINEERING

VOLUME 7 NUMBER 1

MASON BRITTON, *Vice-President*

G. F. NORDENHOLT, *Editor* — K. H. CONDIT, *Consulting Editor*

R. W. CARSON, *Assistant Editor* — F. A. FIRNHABER, *Assistant Editor*

LEONARD CHURCH, *Cleveland* — PAUL WOOTON, *Washington*

W. E. KENNEDY, *Manager*

## Coming Issues

February marks the 50th anniversary of Dr. Hall's discovery of his process for the reduction of aluminum. Fittingly, our February number will contain three outstanding articles relating to aluminum as an engineering material.

One article will be a resumé of the various aluminum alloys, their physical properties and characteristics. The aim of this article is to give a quick reference guide for the selection of the particular alloy desired and to point out the special characteristics of each alloy that might affect the manner of its use.

The second of these articles, contributed by engineers of the Glen L. Martin Company presents a method for the calculation of compression members made of formed aluminum sheet. This article establishes a procedure that enables the designer to evaluate quickly the relative merits of columns of different shape.

For the third of these articles we have gathered pertinent facts and data relative to the design of railroad cars, buses and similar structures, reflecting the experiences of some of the leading engineers in designs of this type.

**McGRAW-HILL PUBLISHING CO., INC.**
**330 W. 42d Street, NEW YORK, N. Y.**

JAMES H. McGRAW, *Chairman of the Board* — MALCOLM MUIR, *President*

JAMES H. McGRAW, JR., *Executive Vice-President* — MASON BRITTON, *Vice-President*

B. R. PUTNAM, *Treasurer* — D. C. McGRAW, *Secretary*

*Branch Offices:* 520 North Michigan Avenue, Chicago; 883 Mission Street, San Francisco; Aldwych House, Aldwych, London, W. C. 2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga.

## CONTENTS for JANUARY, 1936

ENGINEERED AND BUILT IN 8 WEEKS . . . . . 2
How a special automatic polishing machine was designed to be built in a remarkably short time.

MEASURING SURFACE FINISHES . . . . . 5
WILLIS G. MEYERS—How measurements of surface finishes are recorded on the Profilograph and how surface finish might be specified.

LUBRICATION OF SLEEVE BEARINGS—II . . . . . 6
R. G. N. EVANS—Requirements to assure proper oil distribution in a circulating system.

DESIGNING FOR BUSINESS GROWTH . . . . . 12
GEORGE H. GIBSON—Steps in the procedure of developing a new product for the market.

HOW TO MAKE ALIGNMENT CHARTS—I . . . . . 15
M. G. VAN VOORHIS—First of a series showing how to make charts for the solution of equations.

HOW TO SELECT ELECTRIC HEATING ALLOYS . . . . . 19
F. P. PETERS—Physical and electrical properties of twelve types of resistance alloys.

COLOR ILLUSIONS . . . . . 25
HOWARD KETCHAM—An explanation of some common color illusions and how they enter into the problem of color selection.

FOREIGN RADIOS IN PLASTICS . . . . . 29
Four outstanding designs of German, Italian and English models with molded cabinets.

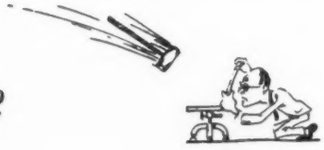
TYPICAL DESIGNS OF FLEXIBLE COUPLINGS—I . . . . . 30
CYRIL DONALDSON—First of a series of four installments showing the design details of various types of flexible couplings.

LENGTH OF MATERIAL FOR 90-DEG. FORMS—II-III . . . . . 39
J. K. OLSEN—Two concluding charts giving the developed length of sheet-metal bends having $\frac{1}{32}$ to 6 in. radii.

Editorials . . . . . 1
Product Developments . . . . . 9
Question and Comment . . . . . 22
News . . . . . 32
Meetings . . . . . 33
New Materials and Parts . . . . . 34
Manufacturers' Publications . . . . . 37
Books and Bulletins . . . . . 37

Published monthly. Price 35c. a copy. Subscription rates—United States, Canada, Mexico, Central and South American countries $3 a year. All other countries $5 a year or 20 shillings. Entered as second-class matter January 17, 1930, at Post Office at New York, N. Y., under the act of March 3, 1879. Cable address "McGrawhill, New York." Member of A.B.P. Member of A.B.C. Copyright 1936 by McGraw-Hill Publishing Co., Inc. Printed in U.S.A. by the Schweinler Press, N. Y.

# *Intimate Correspondence*



## Two Good Companions

PRODUCT ENGINEERING
NEW YORK

I should like to obtain copies of "Modern Hydraulic Control Systems and Circuits" by Hans Ernst, published in your April and May, 1935, issues, and "Modern Applications of Hydraulics" published in the August and September, 1935, issues.

If you have copies of these articles available, or copies of the numbers in which they were published, will you please send me one copy of each billed to me personally at this address. —J.D.
*Cincinnati, Ohio*

THE above is a sample of the many letters we have received requesting additional copies of the articles on hydraulics. It is evident that much attention is being given to the possibilities of applying hydraulic controls and operation. This is further evidenced by letters we have received requesting the names of manufacturers of such equipment. With such specific evidence of the readers' interest in hydraulic operation, we are scheduling further articles on this all-important subject to appear in early numbers.

## The Well Runs Dry

PRODUCT ENGINEERING
NEW YORK

We are very much interested in using a hydraulic system on some special machinery which we are designing. We would like to have a list of suppliers of hydraulic cylinders, pumps, valves and fittings.

If possible, we would like to have a copy of your magazine for August, 1935, in which there is an article on hydraulic systems.
—A.A.K.
*Detroit, Mich.*

IT was a simple matter to comply with the request contained in the first paragraph of this letter. But, unfortunately, we will not be able to satisfy future requests for additional copies of the articles on hydraulic systems that have appeared in recent numbers of *Product Engineering*. Both extra copies of the publication and tear sheets of the articles have been exhausted. However, we will be glad to furnish photostat copies of the articles at 25 cents per page.

## That December Editorial

PRODUCT ENGINEERING
NEW YORK

Just a little note to commend your editorial in the December number and to add a thought or two which might be pertinent.

In general, I have found in the past year and a half that most purchasing agents are only too glad to have me talk with engineers who might be interested in the new materials. And I can say this, from experience, with particular reference to having placed before engineers and designers in the metal working industries, some of the things that this company has been doing.

However, in a few rather notable instances, and by notable I mean large well-known companies, we have run up against a stone wall in the purchasing department. In other words, there are still some organizations where the purchasing department says, "No, we are not buying any tubing. There is no use of your going to anybody."

Yet, only last week, with another company, the largest in its field, employing more than 5,000 people, the purchasing agent not only permitted us to get to the chief engineer, but arranged the appointment. He did this after saying that he was quite confident that they did not have anything of interest as they purchased only a few items of standard mechanical tubing. Yet, after a conference of more than an hour with four engineers, we were able to develop a keen interest in two or three new items.

I mention this as indicating how far out of the way many purchasing agents can be in their knowledge of what might be of interest to their engineers.

Please pardon this rather hastily dictated note, and I hope you will appreciate the spirit in which it is done and that it will give you encouragement to keep up the good work. —J.P.D., Manager
*Bridgeport, Pa.*

MANY thanks for the kind words of encouragement. It was those companies that have not yet fallen in line, at whom our editorial was aimed. And the experience of J. P. D. in his conference with the four engineers is merely one example of the progress that can be made when the door of the chief engineer's office is open to the sales engineer.

## Those Patent Laws

PRODUCT ENGINEERING
NEW YORK

With reference to the Question and Comment department of your December issue and the question "Should Patent Laws Be Scrapped?" I believe that H. N. Booker should be highly commended for his courageous voicing of a general attitude of engineers on this question.

When I read your editorial in the May number (Shall Patent Laws Be Scrapped?) I found the stand you took in the matter rather strange. But I had previously noted a somewhat conservative trend in your editorials in matters other than technical.

It has been stated that the automobile industry has established its own arbitration court to settle disputes relative to patents, because owing to the status of the patent laws as well as the courts, they felt there was no hope of getting anywhere by using the regular procedure of law. Coming from one of the largest industries of the country, this speaks quite a different language than the high sounding claims made in your article in favor of the status quo.

No matter how shady the background of the American Economics Foundation may be, it does seem strange to see an engineering journal ally itself with the lawyers, rather than with the engineers.

You probably have had good reason to expose the foundation. But, you have equally good reason to help improve this impossible condition which the status of the patent law presents, and which by its very nature must continuously get worse. —H.W.S.
*Peoria, Ill.*

*PRODUCT ENGINEERING* allies itself with the engineers, not the lawyers. In our May editorial we deplored the conditions that have created "odds heavily against those who are seeking profit from inventions." We stand by the principle that "by its very nature a patent is meant to be exploited to the maximum monetary benefit of its owner." We took issue with the American Economic Foundation in that they proposed the abolition of "monopolistic features" of our patent system. And, we maintain that, "rob a patent of this feature, it becomes virtually worthless."

On page 32 of this number we all too briefly summarize the recommendations made by a committee appointed by President Roosevelt to study the patent situation. The findings of this committee we consider constructive. The activities of an organization such as the American Economic Foundation, we do not consider constructive. As far as we could learn, the sole purpose of the latter organization was to sway public opinion to the end that the monopoly granted by a patent might be eliminated, at least in certain instances. Their whole activity was apparently "in sharp contrast with the spirit of our patent law." The above quotes are taken from the editorial appearing in our May number. And our editorial did not favor the status quo with reference to our patent system.

Apparently the American Economics Foundation has ceased its activities. So much the better and more power to the committee headed by Dr. V. Bush and the outstanding men who are serving with him. Theirs is a constructive undertaking that should receive unstinted support from all engineers.

# PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. JANUARY 1936 VOLUME SEVEN, NUMBER ONE


## *Those Society Papers*

CRITICISM has been directed against the quality of papers presented at the main meetings of at least one engineering society. Opinions have been expressed that many of the papers are of a sub-elementary nature and have the flavor of personal publicity or company propaganda. The extent to which this situation exists in the various engineering societies is immaterial. It possibly exists to a greater or lesser extent in all the engineering societies and is causing some dissatisfaction among those attending the meetings. Some of the papers presented at the last annual meeting of the American Society of Mechanical Engineers have been criticized with reference to their general quality.

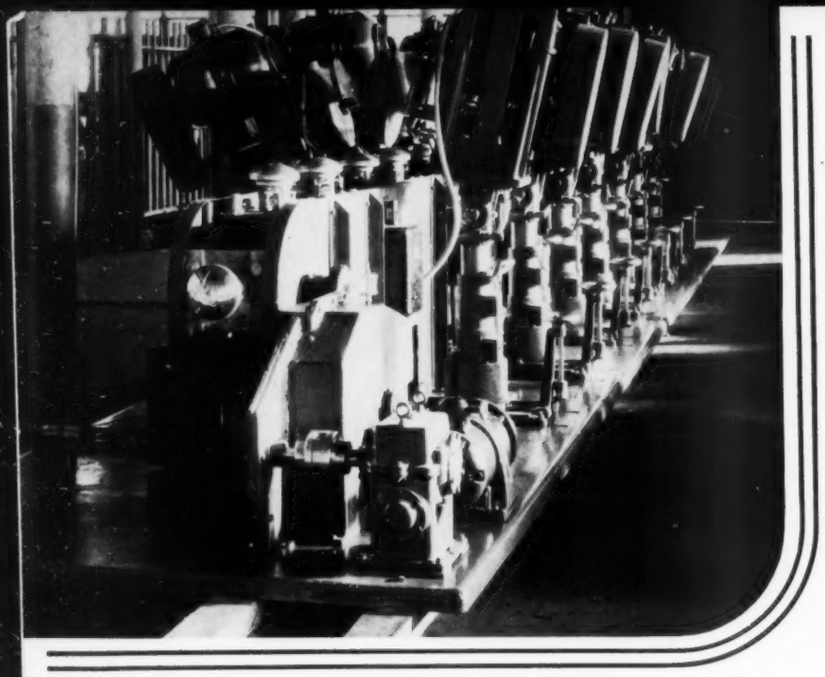
But it must not be assumed that the officers and leaders in the affairs of the society are ignorant of this situation. That they are well aware of it is evidenced by the deep concern they express about the situation and the strenuous efforts that are being made to rectify it.

Committees have long been established in the A.S.M.E. to pass upon the quality of the papers submitted for presentation at meetings. But these committees have not been able to function effectively for reasons beyond their control. Papers that are submitted for presentation at a meeting are supposed to be delivered to the society not later than a specified date. Often the paper is delivered late; so late that there is no time for the committee on papers to pass upon it, reject it, and have the paper replaced on the program with another paper. Hence the undesirable paper stays on the program.

Any society that permits subquality papers to be presented at its meetings or published in its literature is bound to suffer. There is one way of effectively preventing such papers getting on the program. Simply pass and adhere to a rule that no paper may be presented at a meeting of the society sooner than a specified time after it has been delivered in complete form to the secretary of the society. It might be found necessary to run a meeting with a scarcity of sessions. On the other hand, too many papers are presented at some meetings. Quality rather than quantity is the desired goal, and the responsibility lies with the membership.

## *Volume Seven*

WITH this number *Product Engineering* begins its seventh volume. Hand in hand with the return of greater business activity, it has grown steadily. In serving the man engaged in product development, design and research, *Product Engineering* has received increasing support from its readers, contributors and advertisers, of which the editors are fully appreciative. The editorial staff is made up of George F. Nordenholt, editor; Kenneth H. Condit, consulting editor; Robert W. Carson and Fred A. Firnhaber, assistant editors; N. J. Van Ness; Paul Wooton, Washington; Leonard Church, Cleveland.



# *Engineered*

*Fig. 1—Work being polished is indexed successively to 14 adjustable polishing heads, each with a motor*

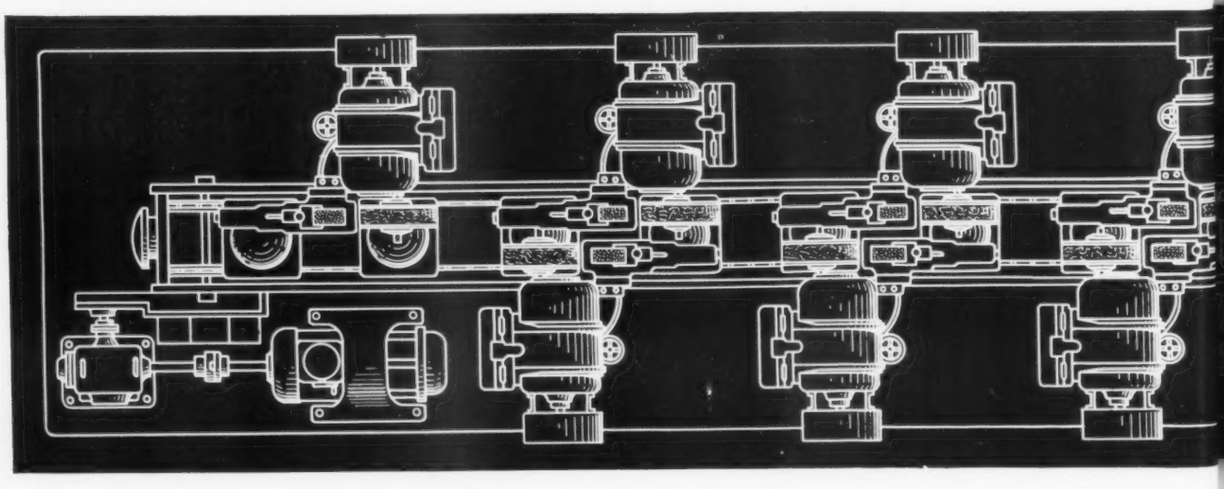
WHEN the Packer Machine Company was given the job of designing and building a special machine for polishing automobile hub caps, three important conditions were specified in the contract. One was that the machine was to be delivered in eight weeks; another was that the machine was to have a capacity of 800 hub caps per hour. In addition to this, the machine was to be adaptable to polishing a variety of parts such as radiator caps, cooking utensils and vacuum cleaner housings. The problem of the engineering department was not only to design the machine in a minimum of time but also to develop one that could be built quickly and meet production requirements.

To expedite the design and manufacture of this machine, three aims were established to be followed in the design procedure. Wherever possible, existing units, such as polishing wheel heads, were to be used. To avoid delay in making patterns, welded construction was to be used in place of castings, except where patterns were already available. Finally, standard unit parts, such as anti-friction pillow blocks, ball bearings, chains, flexible couplings, and transmission units, were to be used wherever possible. This was not only to save time in both design and manufacture, but also to reduce the cost of building the machine.

For engineers experienced in the design of polishing machines, as are the engineers of the Packer Machine Company, the design of a polishing wheel head presents no difficulties. The factors governing polishing are well established. For maximum rate of polishing a given wheel speed and wheel pressure is required. A given minimum amount of polishing compound is needed, and there is a critical time element in the polishing operation that cannot be reduced without affecting the finish. These factors vary with the type of article being polished and the metal of which it is made. For a production machine adaptable to a wide range of products it was necessary to design the machine with a wide range of adjustability for each of the various units as well as for the machine as a whole.

With reference to the grinding and polishing operations, the machine to be built was to take parts such as steel hub caps and in successive steps polish them to a mirror finish. In the initial steps the surface was to be ground by a series of emery-coated wheels, each successive wheel using a finer grade of emery. Then the surface was to be polished to a mirror finish by buffing with successive wheels, using a polishing compound made of clay, rouge, and lime, in the order given. Each of these wheels had to be of different face widths, diameters, and materials, operating at different speeds

*Fig. 2—Work is carried on a conveyor chain past 14 wheel heads, each adjustable as to speed and position. Speed of rotation of the work is controlled by the variable-speed drive on the right, while a similar but larger unit at the left end controls the indexing time*



# *and Built in 8 Weeks ... to Polish Hub Caps*

**How designers of the Packer Machine Company saved engineering, drafting and shop time by using standard parts, individually motorized units and welded construction, for a new automatic polishing machine capable of producing at a specified rate**

and pressures. To perform the complete operation in the required time limit the work had to be divided between 14 separate polishing heads. To operate efficiently and to attain highest practicable rate of output, it would be necessary to have the rate at which the work progressed through the machine adjustable, as well as the speed of rotation of the work while in contact with the polishing wheel. Also, to get maximum output the total polishing time would have to be distributed equally among the 14 heads. These factors also required adjustability for each of the polishing heads, and in addition required adjustability of the machine as a unit in order to adapt it to a variety of products.

Such a machine could be designed for circular indexing of the work, following the design of machines already in use. However, the largest of these machines had only four heads and hence a limited capacity. To group 14 polishing heads around an indexing table would require a machine of excessively large diameter. It was therefore decided to design a straight-line indexing machine, using the same wheel heads already designed and used in the circular type of machine. This reduced the problem to the design of the straight-line indexing table with the necessary speed controls and adjustments. In Fig. 1 is shown the finished machine.

In each of the individual polishing heads, shown in Fig. 4 on the next page, the motor is a totally inclosed, fan-cooled, induction type. Ten of the motors are rated at 7.5 hp., while the four motors for the initial stages are 10 hp. Drive to the wheel spindle is through a multiple V-belt. Spindle bearings are standard ball-bearing pillow blocks using a single ball bearing at the V-belt end and two ball bearings at the wheel. Pillow blocks with integral seals were selected.

Three wheel speeds are obtainable at each head by selecting one of three combinations of V-belt pulleys,

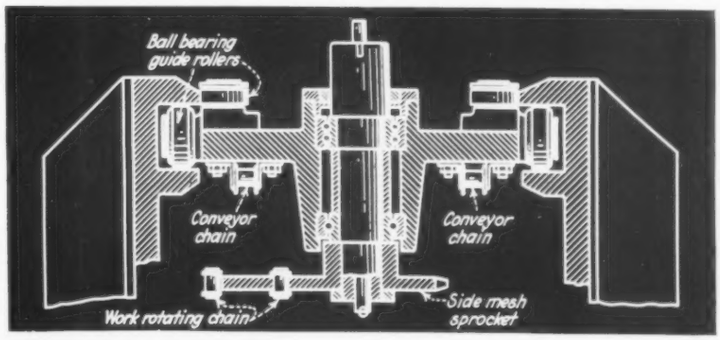
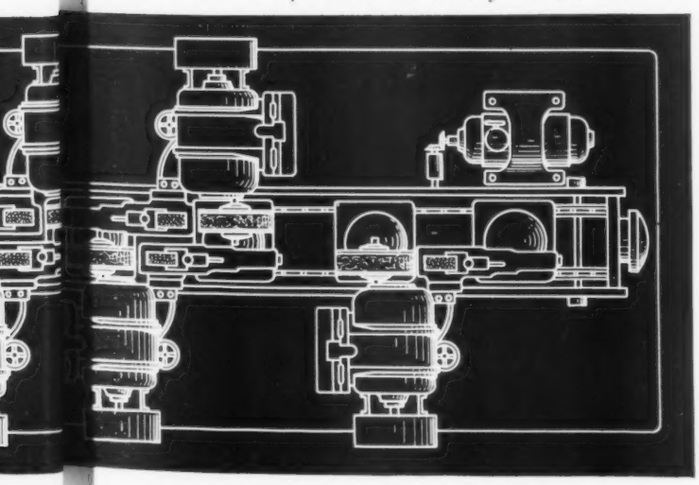



*Fig. 3 (Right)—A side chain drive rotates the work holding spindle on each platen on the conveyor chain*



each pair designed to use the same belt and to give approximately the same center distance. These pulleys are readily interchanged, giving wheel speeds of approximately 2,400, 2,700 and 3,000 r.p.m. with a 1,750-r.p.m. motor. To facilitate removal of pulleys, the motor is mounted on a sliding base which is adjustable by means of a screw. This construction also allows adjustment of belt tension without changing the position of the polishing wheel.

To make it possible to use the same wheel head for each of the 14 stations it was necessary to provide three positioning adjustments. The pivoted mounting of the wheel head on its supporting column permits adjustment of the plane of rotation of the wheel. Height of the wheel shaft, and thus the pressure of the wheel against the work, can be varied by turning the

handwheel at the side of the column, which rotates a jack screw inside the column. The column is mounted on a sliding base which can be moved by a screw to position the wheel transversely. Each polishing head is thereby completely adjustable as to wheel position and wheel pressure.

For greater compactness the polishing head units are mounted alternately on the left and right side of the machine, as shown in Fig. 2. This makes the distance from end to end of polishing heads about 30 ft., resulting in a total length of 42 ft. for the entire machine. To have put all the heads on the same side of the machine would have added nearly 18 ft. to the overall length.

The entirely new portion of the design of this machine is the straight line indexing mechanism. Two factors were involved. The work had to be indexed and held accurately in each position, and while in contact with the polishing wheel the work had to be rotated at a uniform speed in order to present all surfaces to the polishing wheel. Both the rotating speed and the indexing cycle had to be made adjustable to accommodate a variety of work. To accomplish this, a chain type of conveyor is driven by a large Geneva mechanism which is geared through a speed reducer. Power is supplied by a 5-hp. Transitorq, a motorized variable speed reducer, mounted on the front of the bed plate. The hub caps or other parts being polished are held on properly spaced platens mounted on the chain conveyor which passes through the machine and back underneath the working table. The chain passes over sprockets at each end of the machine placed so as to give loading and unloading space at each end. Sprocket shafts are mounted on standard Fafnir roller bearing pillow blocks.

An expanding chuck designed for the part to be polished is mounted on a rotating spindle on each platen. Springs clamp the work in the chucks until released by a cam at the end of the table where the work is loaded and unloaded. To support the work and position it accurately under each polishing wheel as the work is carried down the table, 8 rollers on each platen are used as guides, as shown in Fig. 3. Here again standard unit parts are used, the rollers being ball bearings with the outer race serving as a roller. Each bearing has integral seals and is lubricated for life. In addition to the seals the smaller horizontal bearings have a protecting washer to keep dirt from falling on the bearing.

To provide a means for rotating the work while in contact with the wheel presented a difficult problem. Individual gear drives for each position might have been used, but this construction would have added a large number of parts, greatly increasing points requiring lubrication, and would have been extremely complicated. The solution finally worked out consisted of loop of roller chain running the length of the table. The chain is driven through a bevel gear by the 1-hp. Transitorq shown in Fig. 2 at the right of the machine. The chain meshes with a sprocket keyed to the vertical work rotating shaft on each platen. To hold the chain in mesh with the sprockets, a guide consisting of an alloy steel bar extends the length of the table.

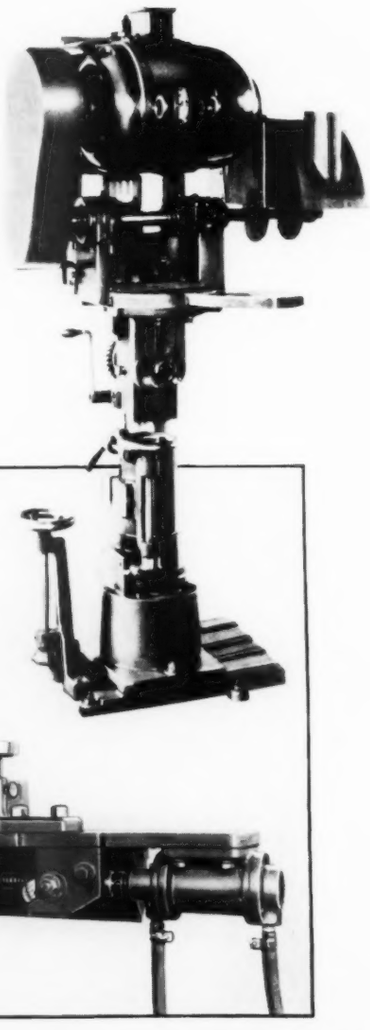
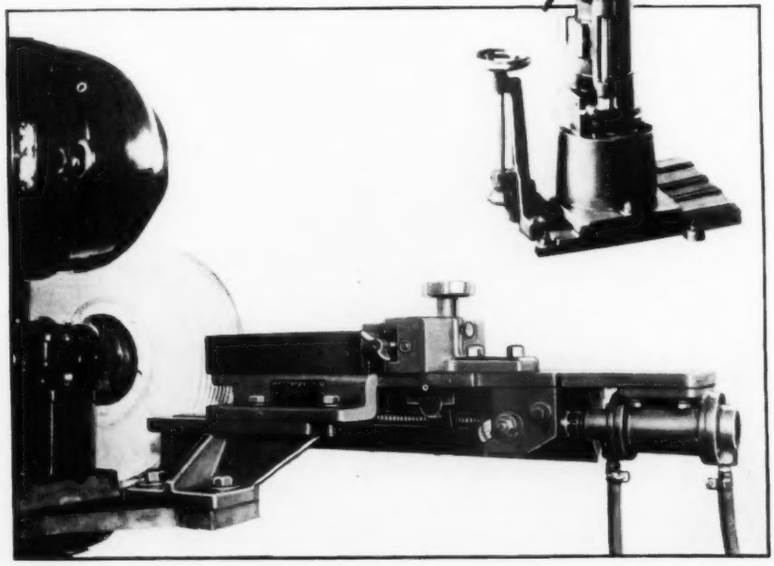


*Fig. 4—On each polishing head desired spindle speeds are obtained by interchangeable V-belt pulleys*

*Fig. 5—The automatic applicator attached to each wheel unit applies a measured quantity of polishing compound during indexing*



Chain travel is in such a direction that in indexing, the travel of the platen nearly equals the chain speed so that the work rotates but little between stations. However, as the indexing movement decelerates, the work rotation accelerates, reaching the operating speed just as the work reaches the polishing wheel.

When the polishing machine is in operation the variable-speed drives on the indexing mechanism and the work rotating chain are individually adjusted. The best combination of indexing time and work rotation can thus be determined for the type of article, character of finish and material being polished.

Ordinarily, an indexing cycle of about 6 sec. is used with half of this time allowed for indexing. The best rotational speed for the work is one that gives 10 to 12 revolutions during the three seconds in contact with the wheel. With the two Transitorq drives the exact speeds desired are readily obtained, resulting in the highest possible production rate.

It is of interest that after being tested in operation and exceeding the specified output, the machine was shipped to the customer three days ahead of schedule.

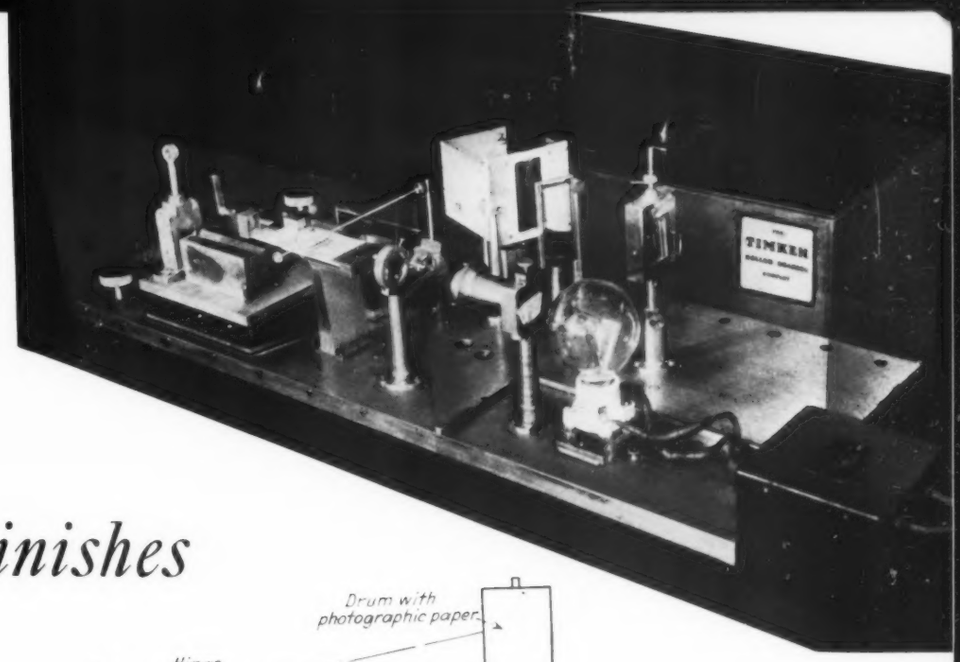
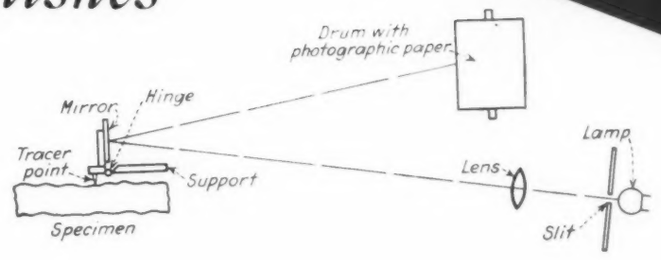



*Fig. 1—In the Profilograph a light beam passes through a lens to a hinged mirror and is reflected to the photographic paper. A diamond is attached to the mirror as shown in the diagram*

# *Measuring Surface Finishes*

WILLIS G. MEYERS




To accurately measure and record the character of finished surfaces, especially for bores of engines, pumps and bearings, Dr. E. J. Abbott, at the University of Michigan, developed an instrument known as the "Profilograph." This research project was sponsored by the Timken Roller Bearing Company.

The apparatus is diagrammatically illustrated in Fig. 1. The principle embodies the accurate recording of the deflections of a light beam. The ray of light is focused on a hinged mirror and reflected on to sensitized photographic paper mounted on a drum.

The specimen is passed under the diamond tracer point attached to the mirror, and the light beam is deflected in exact relation to the contour of the surface. This beam is projected on the sensitized paper so that a curve of the profile is made photographically, with readings measurable in millionths of an inch.

The use of the profilograph has brought to light much new data on the character of finished surfaces and has shown some former theories to be erroneous. It was formerly believed that surface irregularities were in the form of peaks and valleys, but it is now well known that the irregularities are of a decided bluntness. The widths of the peaks and valleys are usually from ten to fifty times their heights. This is a general characteristic of all the surfaces that have been investigated. The dullness is, in all probability, because of the difficulty of maintaining tool sharpness.

An interesting feature of machined surfaces is the wide range in size of the irregularities produced by different methods of finishing. The depth of the irregularities may be a thousand times greater on a rough bored surface than on a lapped or polished surface such as is used on piston pins or gages.

A system of standards has been developed whereby surface finish can be evaluated to make the specification of practical value. The system utilizes a set of three numbers, which take into account the size of the irregularities as well as the character of the surface. After examining profilograms of many types of machining operations in use today, such as those shown in Fig. 2, the best specification was found to be the rate at which the bearing area of the surface increased as the upper part of the profile was removed. Measurements were made of the increase of bearing area on a number of profilograms, and the following specifications devised on the basis of these measurements. Most of the peaks on a bearing surface are removed when the bearing area is 25 per cent, and for a bearing area of 75 per cent only the deeper valleys remain. Accordingly, a surface is defined in terms of three heights as follows:

*Peak Number:* The height between a 2 and 25 per cent bearing area.

*Medial Number:* The height between a 25 and 75 per cent bearing area.

*Valley Number:* The height between a 75 per cent and 98 per cent bearing area.

These specifications are given in millionths of an inch. The limits of per cent of bearing area, from 2 to 98 per cent, were chosen to minimize the effect of a single irregularity.

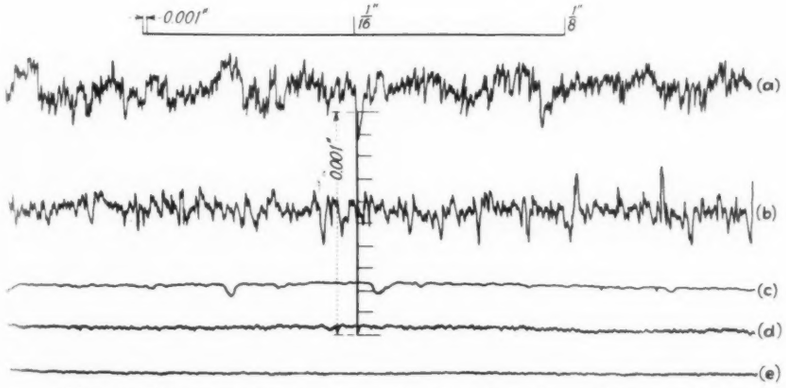



*Fig. 2—Size and shape of irregularities in surfaces that are (a) rough ground; (b) rough honed; (c) lapped; (d) finish ground; (e) finish honed. A vertical magnification of 2,000 times, and horizontally, 30 times, is shown to scale*

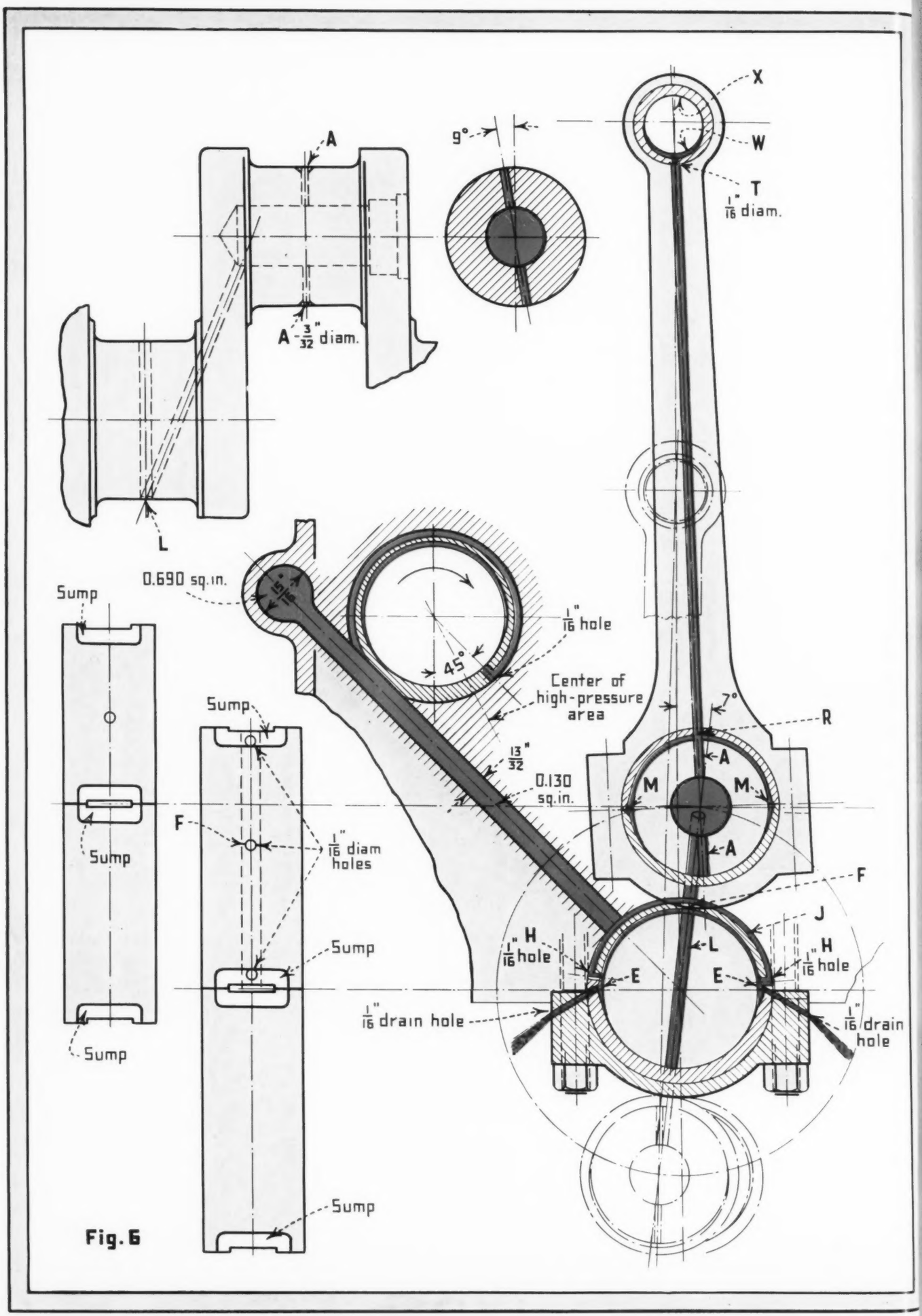



Fig. 6

FIG. 6—LUBRICATING SYSTEM IN AN AUTOMOBILE ENGINE

# *Lubrication of Sleeve Bearings*

R. G. N. EVANS
*Research Engineer, The Bunting Brass & Bronze Company*

**Proportioning of manifolds, ducts and oil inlet holes, their location, and other fundamentals in the design of oil circulating systems for lubrication, such as used in automobile engines**

*PART II*

HAVING established the proper point of oil entry, the second consideration is to provide a sufficient flow of lubricant to maintain the oil film continuously. This is not a difficult problem where individual oilers are supplied to each bearing. But in many machines the problem is to provide an oil-circulating system that will furnish a continuous flow of lubricant to every bearing. The most familiar example of such a lubricating system is found in automobile engines.

In many respects, a lubricating oil circuit can be likened to an electrical circuit. Care must be taken in the design of the lubricating system so that there will not be any "short circuits" and that the oil supply will not be "shunted" around any bearing, thus preventing the lubricant from reaching the high-pressure area.

All other factors being constant, the volume of oil that can flow through a bearing will increase as the bearing clearance increases. That is, the resistance to oil flow decreases as the bearing clearance increases. Unless restrictions are placed in the path of flow, the bearing with the greatest clearance will get the most oil when one manifold is feeding a number of bearings, each with its individual oil line to the manifold. The tight bearings will get the least oil, which amount will often be insufficient. Such a condition can be corrected by placing a restricting orifice just ahead of the oil inlet hole to each bearing. This orifice in the oil pipe must be made large enough so that as much oil as the bearing needs will be delivered. By means of drip plugs or other forms of chokes or orifices, the proper distribution of the oil from the manifold to each of the different supply pipes leading to the bearings will be established.

Frequently instead of using chokes or drip plugs, the same effect can be obtained by a proper proportioning of the sizes of the pipes leading from the manifold to the individual bearings. Thus, in Fig. 8 is shown an incorrectly proportioned manifold with five outlets to furnish lubrication to five main bearings of an automobile engine. The total conducting area of the five outlets or sub-manifolds should be less than the area of the main manifold. But in addition, the circuits fed by each of the sub-manifolds must be correctly designed to assure the desired oil distribution to the various bearings in each of these sub-circuits.

To illustrate the requirements of a correctly designed oil circuit, the accompanying Fig. 6 shows the layout of a system for oiling the camshaft bearings, main bearings, crankpin bearings and wrist pin bearings of an automobile engine. The same principles of lubrication, as demonstrated in this layout, are equally applicable to any machine.

In Fig. 6 the main manifold receives the oil from the oil-circulating pump and distributes it to the various sub-manifolds. The diameter of the main manifold is given as $\frac{13}{16}$ in., corresponding to 0.690 sq.in. cross-sectional area. Leading off from this manifold are five sub-manifolds such as indicated in Fig. 8. For a proper distribution of the oil it is necessary that the cross-sectional area of each of these sub-manifolds be less than one-fifth of the cross-sectional area of the main manifold. At the same time, the size of the sub-manifold should be made as large as possible in order not to offer too much resistance to the flow of the oil. Therefore, the diameter of the sub-manifold has been made $\frac{13}{32}$ in., giving a cross-sectional area of 0.130 sq.in. This is slightly less than 0.138 sq.in., which is one-fifth of the cross-sectional area of the main manifold.

The sub-manifold supplies oil to the camshaft bearing and the main bearing. As indicated in Fig. 6, the high-pressure contact area of the camshaft bearing extends to a point somewhat less than about 45 deg. to the right of the vertical center line of the bearing, for a clockwise rotation as indicated on the drawing. This particular design is for a chain drive to the camshaft. If the camshaft were gear driven, its direction of rotation would be counter-clockwise and the high-pressure bearing area would be to the left of the vertical center line.

As shown in Fig. 6 there is a circumferential groove on the outside of the camshaft bearing beginning at the point where it receives the oil from the sub-manifold and continuing around to the $\frac{1}{16}$-in. diameter oil inlet hole. This groove conducts the oil from the sub-manifold directly to the oil hole which passes through the wall of the bearing at a point just ahead of the high-pressure area, in this instance, 45 deg. to the right of the vertical center line. It should be noted that the circumferential groove should not be placed in the inner wall of the bearing, as that would break up the oil film and would in effect be the same as putting the oil inlet hole in the clearance area.

Had the oil inlet hole been placed at the point of tangency between the sub-manifold and the camshaft bearing, it would have been necessary for the journal to carry the oil through an angle of about 290 deg. before reaching the high-pressure area. Most of the oil would have been lost through end leakage and spillage before

reaching the high-pressure area, resulting in insufficient lubrication at the point required.

In Fig. 7 is shown the effect of having the oil inlet hole through the bearing wall at the point of tangency of the sub-manifold. There would be an excessive loss because of leakage through the clearance area. With the inlet hole in the clearance area it would be necessary to have an oil inlet hole $\frac{5}{32}$ in. in diameter in order to have its area at least equal to the area through which spillage might occur. It is also shown that if the inlet be placed near *A* in Fig. 7 a hole $\frac{1}{16}$ in. in diameter would be sufficient, indicating that the pressure drop at this point in the circulating system will be greatly reduced when the oil inlet is located properly.

Applying this to the design shown in Fig. 6, were the oil inlet hole to the camshaft bearing located at 45 deg. to the left of the center line, just ahead of the clearance area of the bearing, the camshaft bearing would have to be furnished with approximately sixteen times as much lubricating oil and even then the lubrication of the bearing would probably be unsatisfactory.

With only a $\frac{1}{16}$-in. diameter oil inlet hole to the camshaft bearing, there will be a correspondingly small pressure drop in the sub-manifold at this point. Thus, there will be plenty of pressure for the oil supply to the remainder of the bearings. The main bearing gets a constant supply of oil through the two $\frac{1}{16}$-in. diameter holes *H* feeding into the sumps *E*. These sumps are formed by the chamfer at the parting line of the bearing halves, but do not extend to the ends of the bearing. Here again the oil is fed from the sub-manifold to the hole *H* through a circular groove on the outer wall of the bearing.

Two oil holes are supplied at the main bearing because of the reversal in the direction of the bearing pressure, the one hole serving when the bearing pressure is downward and the other hole serving when the bearing pressure is upward.

In addition to the $\frac{1}{16}$ in. diameter hole *H*, two drain holes, also $\frac{1}{16}$ in. diameter, are provided. These holes are drilled through the main bearing housing and lead from the ends of the circular groove *J* out into the crankcase. The purpose of the holes is to provide a channel for draining off foreign matter in the oil.

The total area of the four $\frac{1}{16}$-in. diameter holes is 0.012 sq.in., which is appreciably less than the cross-sectional area of the sub-manifold, which is 0.130 sq.in. With reference to the groove *J* in the outer wall of the bearing, its cross-sectional area must be greater than twice the area of a $\frac{1}{16}$-in. diameter hole, there being two $\frac{1}{16}$-in. diameter holes at each end of the groove.

In the auxiliary view is shown how the crankshaft is drilled to provide a path for the oil to the crankpin. The drilled hole *L* registers with the holes *E*, *E* and *F*. Passing through the holes *A* in the crankpin, the oil is fed into the sumps *M* and *M* in the crankpin bearing. These sumps are formed by the chamfer at the bearing parting line. From the sumps the oil feeds onto the unbroken bearing surfaces and is rolled out in advance of the shifting high-pressure area as the crank rotates.

With the holes *A* each $\frac{3}{32}$ in. in diameter, they have a total cross-sectional area of 0.014 sq.in. The holes are at approximately 9 deg. off the vertical center line. The hole *F* is $\frac{1}{8}$ in. in diameter and is drilled in the main bearing at about 7 deg. to the right of the center line. In order to keep the holes *F* and *L* in register over a longer period of time, the hole *A* is countersunk to $\frac{5}{32}$ in. in diameter, thereby giving an overlap throughout about 12 deg. of crank rotation.

From the crankpin, the oil feeds through the $\frac{1}{8}$-in. diameter hole *R* in the bearing, through the hole *S* in the drilled rod, is released through the $\frac{1}{16}$-in. diameter hole *T*, thus into the wristpin bearing. With the hole *T* only $\frac{1}{16}$ in. in diameter, a back pressure is established in *S*. When the pressure on the wristpin shifts from the point *W* to the point *X*, the clearance on the lower side of the wristpin permits a spurt of oil to spill out through the wristpin bearing.

To completely understand this action, the two positions of the crank are shown in the drawing, the lower position being shown in dashed lines. On a conventional motor, the drilled hole *A* in the shaft crankpin comes in register with *R* in the connecting rod at the top dead center. At this point the hole *A* is blocked off for approximately 7 deg. This varies with the relation of crank center line to cylinder center line and with the length of rod. The piston pin has its contact at *W* under pressure during three of the four cycles, and the entrance of oil to the bearing surface is blocked off during these strokes. On the intake stroke, after the crankpin passes top dead center the point of bearing pressure shifts to *X*, freeing the oil inlet *T*, and thereby releasing the pressure built up in the holes from *F* to *S*. This furnishes a supply of oil to the wristpin bearing surfaces sufficient to give adequate lubrication on the remaining three strokes of the cycle.

*Fig. 7—Placing the oil inlet in the clearance area results in excessive end leakage which causes a large pressure drop at that point in the system. Fig. 8—Total area of all the sub-manifolds must be less than that of the main manifold*

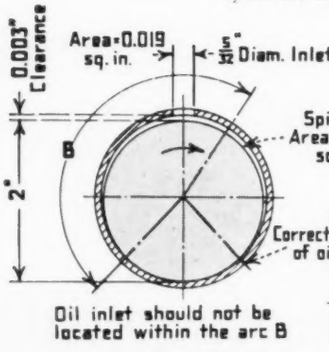



Fig. 7

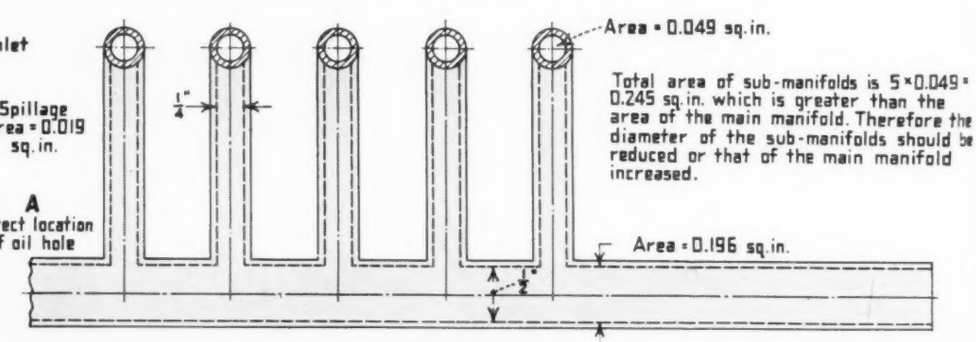

Area = 0.049 sq.in.
1/4"
Total area of sub-manifolds is 5×0.049 = 0.245 sq.in. which is greater than the area of the main manifold. Therefore the diameter of the sub-manifolds should be reduced or that of the main manifold increased.
Area = 0.196 sq.in.
1/2"

Fig. 8

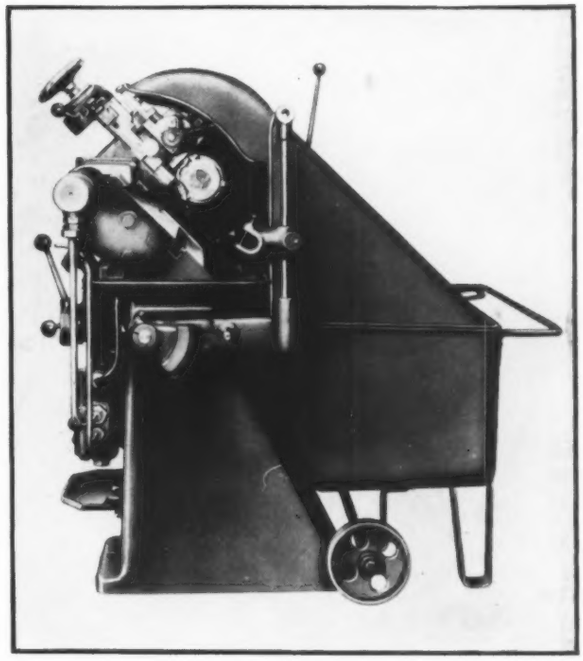
# PRODUCT DEVELOPMENTS

## *German Lathe With Inverted Tool to Facilitate Chip Removal*

● To utilize the cutting speeds permitted by tungsten carbide tools, a German lathe designed by Magdeburger Werkzeugmaschinenfabrik has the cutter placed with the edge down. As shown in the accompanying illustration, chips flow downward, and slide down the inclined rear face of the bed, into a two-wheel truck.

Maximum spindle speed is 6,000 r.p.m. Journals are nitrided and run in adjustable sleeve bearings that are flood lubricated. The spindle is belt driven from a 10 hp. motor that is flange mounted at the left end of the lathe.

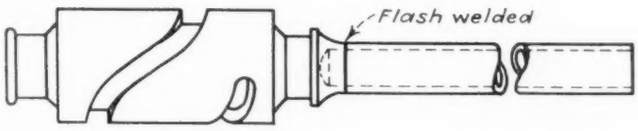
The bed has a triangular section and the ways, protected by aluminum aprons, are placed so that the cross slide inclines downward. Variable hydraulic feed is used giving a speed range of 1 to 40. Fixed stops at the end of travel operate safety valves in the hydraulic system.



*To facilitate removal of chips, the tool slide on this German lathe is inverted and slants downward*

•

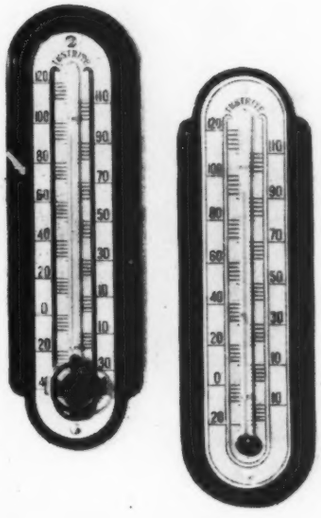
*Steering shaft assembly consisting of a machined cam resistance welded to a tubular shaft*




## ● *Resistance Welded Steering Shaft*

In steering gears, the cam groove at the lower end of the steering wheel shaft must be machined for a length of about 6 in. to a diameter larger than is required for the steering wheel shaft. To machine the entire shaft from one piece would be expensive, while safety considerations require a trouble-proof assembly, if made of two parts.

The steering shaft shown here is now being made at high speed and low cost from two separate parts. A tube 0.885 in. in diameter is used for the shaft and a separate piece for the cam. After the cam groove has been machined and the hollow shaft cut to length, the two parts are resistance welded in a Thomson-Gibb automatic flash welder at the rate of 200 assemblies an hour.



*Conservatively modern is this new thermometer designed by Walter Von Nessen for the Testrite Instrument Company. The fluted bakelite base is molded by Boonton. In both models the same base is used, but by inverting it and adding a guard and an etched plate a model in each of two price groups is obtained with but one molded part*

## ● *Aluminum in Extension Platforms*

The main banking room on the 49th floor of the Irving Trust Building in New York is 32 ft. high. In order to clean the ceilings and walls and to service ceiling lamps in this room, and also other high rooms in the building, a collapsible ladder must necessarily be carried from floor to floor on elevators. Telescopic lifters designed for such applications therefore must be small and light enough to be transported on the building elevators.

In the Economy lifter, designed and built by the Economy Engineering Company, the use of aluminum made possible telescoping elevating platforms light enough to be carried on the elevators. The telescoping frames are made of drawn aluminum sections, cold riveted with aluminum

*By using aluminum sections, the Economy telescoping lifter in the Irving Trust Building can be carried from floor to floor on passenger elevators*

rivets. Base sections are welded from rolled steel shapes.

The lifter illustrated, in use at the Irving Trust Building, has a base frame 28 in. wide and 54 in. long, and the collapsed lifter is only 78 in. high. The machine is hand operated, and is carried on ball-bearing wheels individually adjustable to allow for uneven floors.

## • *New Magnet Alloy Improves Microphone*

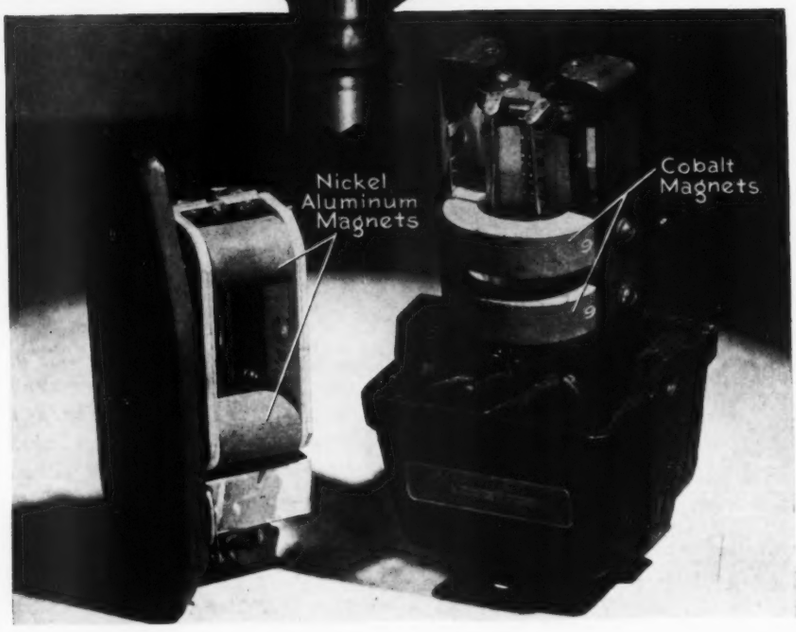
In improving tone fidelity, microphones for radio or public address systems have been developed in which vibrations of the diaphragm in a strong magnetic field generates the current which is then amplified. In this velocity type of microphone, as it is called, a narrow corrugated strip of aluminum foil is suspended in the field of a strong permanent magnet. Because of its light weight, the strip readily follows the sound vibrations of the air. Relative movement between the strip and the permanent magnet field induces in the strip an alternating current, which is amplified for transmission. Sensitivity, however, requires a strong magnetic field.

For convenience, the microphones usually are mounted on floor stands, so that a light weight and compact design is desirable.

In a new velocity microphone designed by the Amperite Company, overall dimensions as well as weight are reduced by the use of a new

*In the Amperite velocity microphone the vibration of the diaphragm in a field of strong permanent magnets generates the current*

*The cobalt steel horseshoe magnets were replaced in the redesigned unit by smaller cylindrical magnets of nickel-aluminum alloy*



type of permanent magnet made by Indiana Steel Products Company. As shown at the right in the accompanying illustration, the former model used conventional horseshoe magnets forged from cobalt steel. These magnets are replaced in the new design shown at the left by two cylindrical cast magnets of a nickel-aluminum alloy. The screw holding each magnet in place passed through a cored hole.

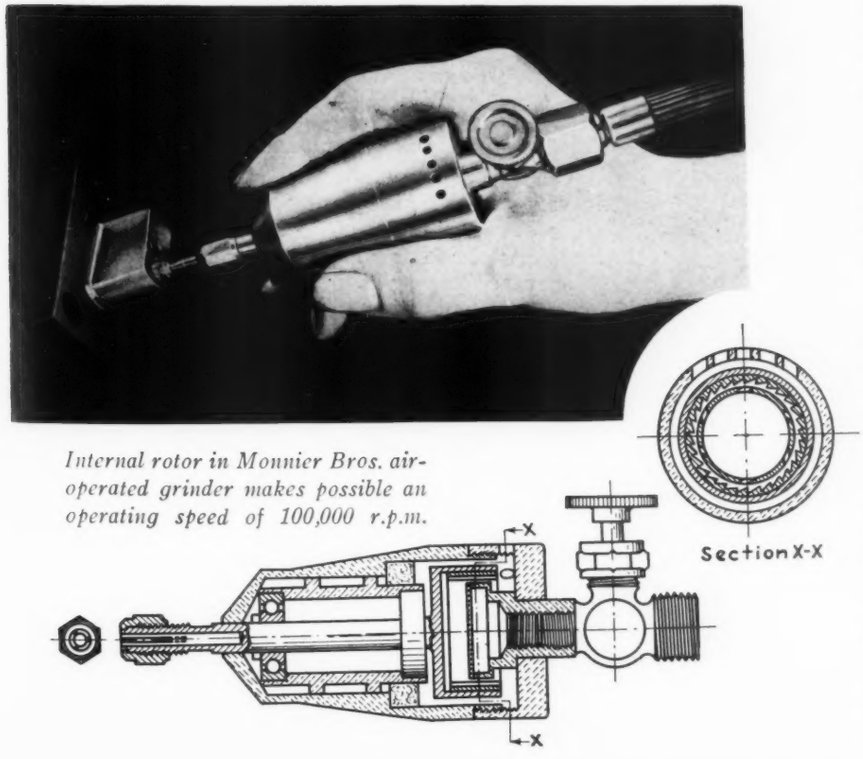
Because of the high coercive force of the nickel-aluminum alloy, the magnets can be made much shorter with consequent reductions in size and weight, at the same time increasing sensitivity. Better performance is also obtained since the new magnets are less affected by vibration or changes in temperature.

## • *Lubrication at 100,000 R.P.M.*

Liquid lubricant cannot be used in ball bearings at extremely high speeds since churning results in generation of heat that destroys the lubricant. In the Monnier 100,000-r.p.m. air-operated grinder shown in the acompanying illustration, the two high-speed ball bearings are lubricated by oil vapor picked up by circulating air as it passes through an oil-soaked felt wick. The circulating air is bled from the exhaust chamber and leaves at the spindle thus preventing abrasive dust from reaching the bearings.

Rotor vanes are internal. This construction not only reduces the outside diameter and consequently the centrifugal forces on the rotor, but also makes possible a reduction in the weight and size of the grinder.

With an overall length of 5 in., the grinder shown here weighs but $8\frac{1}{2}$ oz., a cast aluminum body being used to attain this low weight.




*Internal rotor in Monnier Bros. air-operated grinder makes possible an operating speed of 100,000 r.p.m.*

## • *Random Jottings*

Because of the large amount of moisture used in the process of printing postage stamps, the consequent change in dimensions of sheets of stamps makes perforation difficult to control. The space between stamps is only $\frac{7}{64}$ in. wide, while the perforations themselves are $\frac{3}{64}$ in. in diameter. An experimental machine now in operation at the United States Bureau of Engraving and Printing in Washington is controlled by a photo-electric registering device through a variable speed drive to obtain automatic register of these perforations. This photo-electric control greatly increases the output of the machine.

* * *

According to his own statement, the manufacturer of a molding machine seems to have achieved perfection for, according to his literature, "This machine is scientifically designed for the highest practical efficiency and includes the best possible material for each part. It is made by skilled mechanics and a strictly interchangeable manufacturing basis is adhered to."

* * *

Platinum metal is now essential in the design of spinnerettes for rayon manufacture. Through a number of small holes in this device, a solution containing caustic soda is forced, forming filaments from which the rayon threads are spun. Platinum successfully withstands the corrosive action of the caustic soda.

* * *

Shear blades are used to cut surplus glass from the suction mold used in machines for making water glasses. Since the glass is molten the blades operate at high temperatures. In machines in the Libby Glass plant shear blades faced with Stellite outlast hardened steel blades by more than ten times.

* * *

Beetleware has contributed to the "Better Light—Better Sight" movement by the introduction of a new line of molded light fixtures. A single bulb is used in the fixture, but the diffusing power of the plastic material eliminates glare.

* * *

Bakelite in various colors is used in combination with china, chromium plate and gold plate in a new line of desk sets made by the W. A. Sheaffer Pen Company.

* * *

The detachable Timken drill bit is Parkerized not only to resist rusting while in use but also to protect the surface during storage in damp atmospheres.

* * *

Pump bodies and impellers for coal washing come in contact with an abrasive slurry that limits the life of ordinary iron and steel parts to about two or three weeks. By using Ni-Hard, a nickel alloy cast iron, the McNally-Pittsburgh Manufacturing Corporation finds no apparent decrease in the efficiency of the pump after six months in service.

*Marketing the product before it has been tried out may result in failure*

# *Designing for Business Growth*

GEORGE H. GIBSON

IT IS a commonplace occurrence for businesses to dwindle, dry up and disappear for want of new developments; for unsound ideas to be taken up haphazardly; for good ideas to be neglected until too late or projects to be abandoned when half done. Meritorious plans sometimes become entangled in patent difficulties. Many a new invention which started out with all the elements of success has failed or only half succeeded because some essential step has been slighted or omitted.

The invention or "hunch," or even a working drawing, is at best only a beginning. Much time, labor and expense ordinarily intervene and many hazards are to be faced before the fruits of invention can be gathered as business profits. The best provision against loss and the most reliable insurance for ultimate success is to be found in rational methods for gathering facts, selecting objectives, directing research, and exploiting results. Direct personal observation, supplemented by comprehensive reading of industrial and technical literature and of patent office records, and intelligent statistical surveys are desirable preliminaries to entering new fields. The consideration of each proposed undertaking should be supported by studies of:

1—Applications and probable markets
2—Advantages of new product
3—Facilities for and the cost of production
4—Method and cost of distribution
5—Competitive situation
6—Patent situation
7—Capital investment involved

Listing the information obtainable with respect to these headings, brings out the undesirability of certain projects or features, clarifies understanding of the matter, or leads to a more advanced point of view. It will tend to eliminate the waste of imperfectly planned work. Before becoming committed too much to a specific development, other possible ways and means of accomplishing the same result should be sought out and compared. Doing so before money is invested may save abandonment of the undertaking later on and will probably result in a better invention and better patents, or in the opening up of a larger field. Where an invention is not generic, control of a number of species may be necessary in order to secure sufficient monopoly to warrant the expenditure required for development. One of the shortcomings of amateur inventors is pausing before the tasks of inventing is half finished.

Before beginning work on a projected process, method or machine, it should be analyzed into its component elements in order to determine what parts, features or steps depend upon information still to be gathered by research or experimentation. An itemized estimate of the cost of research, experiments, development and, if possible, practical try-out, should be prepared.

Experimental work, in particular, should be subdivided into elementary steps, so that only one variable or unknown will be involved at a time. Otherwise, the evaluation of results may be complicated or uncertain. After the undertaking has been analyzed into progressive steps, expenditures can be budgeted up to some definite point and, when this point is reached, a report of what has been accomplished will serve as the basis of a new appraisal. If this is satisfactory, a further objective can then be set up and the procedure repeated.

While the patent situation should receive adequate investigation it is not desirable to rush into the patent office every time that some one hatches an embryonic idea. Applications for patents can generally be held in abeyance so long as diligence continues in the prosecution of the subject matter which is believed to be patentable. In fact, the quality of the patent will, as a rule, be better and the expense less if the filing of an application be deferred until the device has been proved out in use, due regard being had, of course, to the legal limitation of public use to two years before filing.

Patent research can be of great service during the inventing and developmental stage, but patent attorneys, even though shrewd in writing specifications and in drawing claims, cannot always be relied upon for exhaustive exploratory searches nor for constructive thinking about the narrowness or breadth of the field open to the new invention. I have in mind an exceptionally able attorney who, after having made a search and filed a patent application, was confronted with the fact that certain features of the new invention were covered by claims in a patent which he previously had

taken out for another client. His comment was that he had been instructed to search with regard to patentability and not with regard to infringement. The device had been completed to the point of going into production, but fortunately it was possible to obtain a license from the owners of the patent upon reasonable terms.

## *Dangers of Incompetent Advice*

Biased judgments are, in particular, to be avoided. The technical employees of concerns in the same line of business, having possible a sub-conscious feeling that if a new idea has merit they themselves should have thought of it, frequently formulate supposedly practical or theoretical reasons why it will not work. Numerous instances can be cited where the employer, accepting their advice with confidence and turning down the proffered invention, has later on seen the invention doing good service for a competitor. Often more intelligent consideration for an invention can be obtained from a concern in a somewhat different line of business.

Another reason for avoiding a manufacturer in the same line when seeking a backer for a new invention is that its successful introduction may have the effect of wiping out the existing business. This fact may warp his judgment and that of his advisers. The attitude of some manufacturers when a patented invention is submitted to them would seem to indicate that they regard the offer as the equivalent almost of an attempt to levy blackmail. They overlook the fact that inventive thought is free and that adoption of the scheme by a competitor may be worse for them than a fire.

The individual inventor, before concluding terms with a manufacturer, should consider the possibility that the latter may desire control of the patent in order only to have a reserve of new ideas or improvements to be taken up in case the current lines should decline or should not utilize the full capacity of the plant and organization. Or for other reasons, the manufacturer may wish to pigeon-hole the patent altogether. In either event, the likelihood of the inventor ever receiving more than minimum royalties is small. His prospects might be much brighter with a concern having less resources but depending upon the new idea for a large part of its profits.

Business heads are frequently misled by honest but incompetent advice. As for example, it was suggested to a manufacturer of open feed-water heaters that a combined feed pump and open heater be developed to use exhaust steam for heating feed water on locomotives. Such a heater would have marked advantages over the tubular heaters then used.

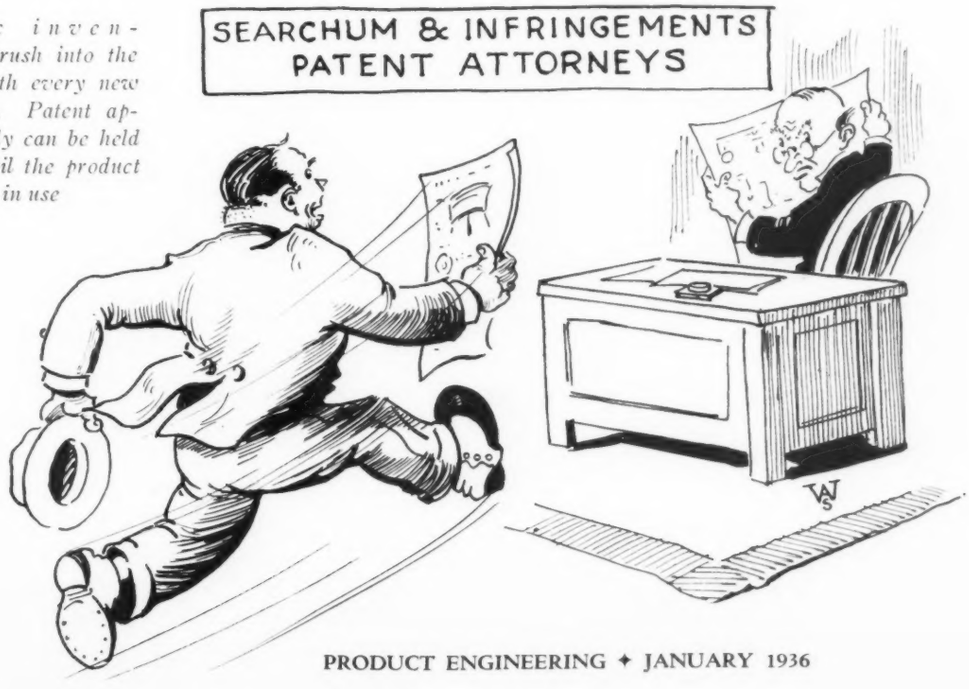
The manufacturer thought well enough of the suggestion to set one of his best draftsmen at preparing working drawings. This man, however, upon visiting a locomotive building plant to obtain limiting dimensions, came to the conclusion that there was no space on a locomotive for such a device and, because of his report, the project was dropped. Subsequently, however, the same idea, originated independently, was developed by another manufacturer whose sales of the device ran into millions of dollars.

Over-eager general sale of the first model of a new invention is usually to be avoided. Unsuspected defects consequent upon oversight in design, inexperience in production or unforeseen requirements of practical use, may show up. Some concerns, long experienced in the developing and marketing of scientific and engineering equipment, wait for a year or more between the completion of laboratory and drafting room development and release to the sales department. During this interval a limited number of machines are placed on trial in the plants of friendly customers, where they are inspected frequently and watched closely for imperfections. In this way risk of damage to reputation and dampening of salesmen's confidence and enthusiasm by too numerous "trouble cases" is reduced.

## *Mistakes of Premature Marketing*

The risk incurred in offering an unseasoned new invention for general use may be seen in the experience of a manufacturer of steam specialties, whose engineers developed a new instrument superior in principle to similar devices then on the market and for which undoubtedly a large demand then existed. In the haste

*Overenthusiastic inventors needlessly rush into the patent office with every new embryonic idea. Patent applications usually can be held in abeyance until the product has been proved in use*



to cash in, however, quite a number of instruments were at once put out through the regular sales organization, which, it may be remarked, had only limited experience in selling and in servicing instruments. The result was that various minor shortcomings in materials and design of parts developed, entailing excessive servicing charges and leading to expressions of dissatisfaction from salesmen as well as from customers.

A hasty attempt to remedy the disclosed faults was then made and the salesmen were called in for new inspiration and instruction and a fresh start. But more "bugs" appeared and the correction and reinvigoration process was repeated, not once but several times. The result was that when eventually all causes of trouble had been eliminated, many of the sales representatives had lost both faith and money, and sales lagged. After struggling for a few years with this condition, new sales outlets were established through organizations specializing in the selling of instruments, but by that time competitive developments had greatly restricted the market. Thus an otherwise valuable patent was wasted by premature marketing.

Nevertheless, time is most emphatically the watchword in respect to competitive commercial exploitation. The seventeen years monopoly granted to new inventions by the patent law is often insufficient to cover the several phases of invention, experimentation, design, practical try-out and business organization. And after the new article has at last been perfected and placed upon the market, volume of business and profit may go to others who, unlike the originator, are not handicapped by the capital charges of development and introduction. Once commercial exploitation begins it is desirable that it should proceed energetically and adequately with respect to devices and ideas upon which good and enforceable patents are not obtainable. Speed with an aggressive marketing policy is the best means of escaping the competition by imitators.

### *Commercial Use Strengthens Claims*

The patent situation, also, is improved by diligent and successful practical application. An invention is supposedly perfect when the patent is applied for and theoretically the owner of a patent can do with it as he likes, including doing nothing at all, without impairment of his rights. At the same time the courts are unsympathetic to any such dog-in-the-manger policy and scan with narrowed eyes the claims of "paper" patents unsupported by wide commercial use. In a case in mind, the judge admitted that both patentee and infringer were seeking to do the same thing, but followed with the remark that the patentee was doing it on paper in patents while the infringer was doing it in plants. Then he grudgingly proceeded to hold the infringer only under such claims that were plainly inescapable under any possible interpretation. Had the patentee been able to show commercial application over-shadowing that of the infringer, in all probability other and important claims would have construed favorably.

---

*Welding—A Step in the Manufacture of "Certified" Baskets for Centrifugals Made by American Tool and Machine Company*

# *How to Make Alignment Charts*

M. G. VAN VOORHIS

**Detailed procedure for making charts for the solution of equations, with examples for each of the type equations treated. The next installment will appear in February**

*PART I*

IT IS the purpose of this series of articles to provide instructions on "how to make" nomographic or alignment charts for the solution of engineering and other formulas. Major stress is placed on how to handle the various types of equations. Such theory not essential to the understanding of the procedure in making the charts is given a position in the background. Graphical construction methods are described wherever they are possible.

The material is presented with a minimum of text and a maximum of illustrations. Examples are given with every type equation to demonstrate the detailed procedure for making the charts according to the directions which are provided. The first formulas treated are of the simplest type. As groups of equations are described, their relations to each other and to certain general type forms become obvious. By this plan of presentation, the material is gathered together to build a theory as contrasted with presentations wherein an all-inclusive theory is traced to its many branches.

Nomographic charts, while by no means a new method for solving equations graphically, are being appreciated more fully. While it may seem that one more text on this subject is superfluous in view of the wealth of material which has been written, it has been the experience of the author in presenting a course of nomography to technical men that there is need for a more direct approach to the subject.

In general there are two theoretical approaches to the subject—by plane and analytical geometry and by determinants. The author favors the former and uses it here chiefly because determinants are a relatively unfamiliar branch of mathematics. The following four textbooks to which the reader is referred for a more detailed presentation of the theory of the subject are evenly divided in their treatment:

"A First Course in Nomography," by S. Brodetsky (Open Port Publishing Co., Chicago, Ill.); "Graphical and Mechanical Computation, Part I, Alignment Charts," by Joseph Lipka (John Wiley & Sons, Inc., New York, N. Y.); "Design of Diagrams for Engineering Formulas," by Laurence I. Hewes and Herbert L. Seward (McGraw-Hill Book Co., New York, N. Y.); and "The Nomogram," by H. J. Allcock and J. Reginald Jones (Pitman Publishing Co., New York, N. Y.).

The simplest equation that can be written is that for the sum of two simple variables. The determination of the sum by the usual method is so simple that it would be impractical to construct a chart for the solution of the equation. But the directions are given here because they present the fundamentals and afford a comparison with the directions given later for the construction of charts for more complex equations.

## *Nomogram for $x + y = z$*

Draw two parallel lines for the $x$ and $y$ scales, as in Fig. 1. Determine for the particular equation to be charted the maximum and minimum value of $x$ and $y$, respectively, that are to be included in the chart. Subdivide one line uniformly with a scale for $x$ within the limits established and subdivide the other line similarly for $y$, the two scales ascending in the same direction. The size of each scale is independent of the other and may be as large as possible as the space allows.

Under these conditions of layout the location of the $z$ scale, as shown in Fig. 1, will always be a line parallel with and between the $x$ and $y$ scale lines. Two methods may be employed to find the location of this line, a construction method and a formula method.

CONSTRUCTION METHOD FOR LOCATING $Z$ SCALE—Select a value for $z$ within the range of its scale and satisfy the equation twice with two sets of the values of $x$ and $y$. Draw two lines connecting the corresponding values of $x$ and $y$ on their respective scales. The intersection of these two lines locates the $z$ scale line, and will also be the selected value of $z$ upon the $z$ scale. Repeat this operation to obtain a second value of $z$ on the scale and subdivide the $z$ scale uniformly.

FORMULA METHOD FOR LOCATING $Z$ SCALE—To determine the scale units by formulas, it can be shown by similar triangles, as in Fig. 2, that:

$$g = \frac{m_x}{m_x + m_y} d \qquad (1)$$

$$h = \frac{m_y}{m_x + m_y} d \qquad (2)$$

$g$ = distance from $z$ scale to $x$ scale
$h$ = distance from $z$ scale to $y$ scale
$d$ = distance between $x$ and $y$ scales = $g + h$
$m$ = length of scale units for the scale designated by subscript

Laying out these distances and scale values, as indicated in Fig. 1, gives the desired construction.

PROOFS OF CONSTRUCTION AND FORMULAS—To prove the method of locating the $z$ scale by the construction method, it is necessary to show that the loci of the points of intersection of the lines joining corresponding $x$ and $y$ values will be a straight line parallel to the $x$ and $y$ scales, and also that the readings on

**FIG. 1**

*Nomogram for determining the sum of two simple variables. Construction of this simple chart presents the fundamentals for charts for more complex equations*

**FIG. 2**

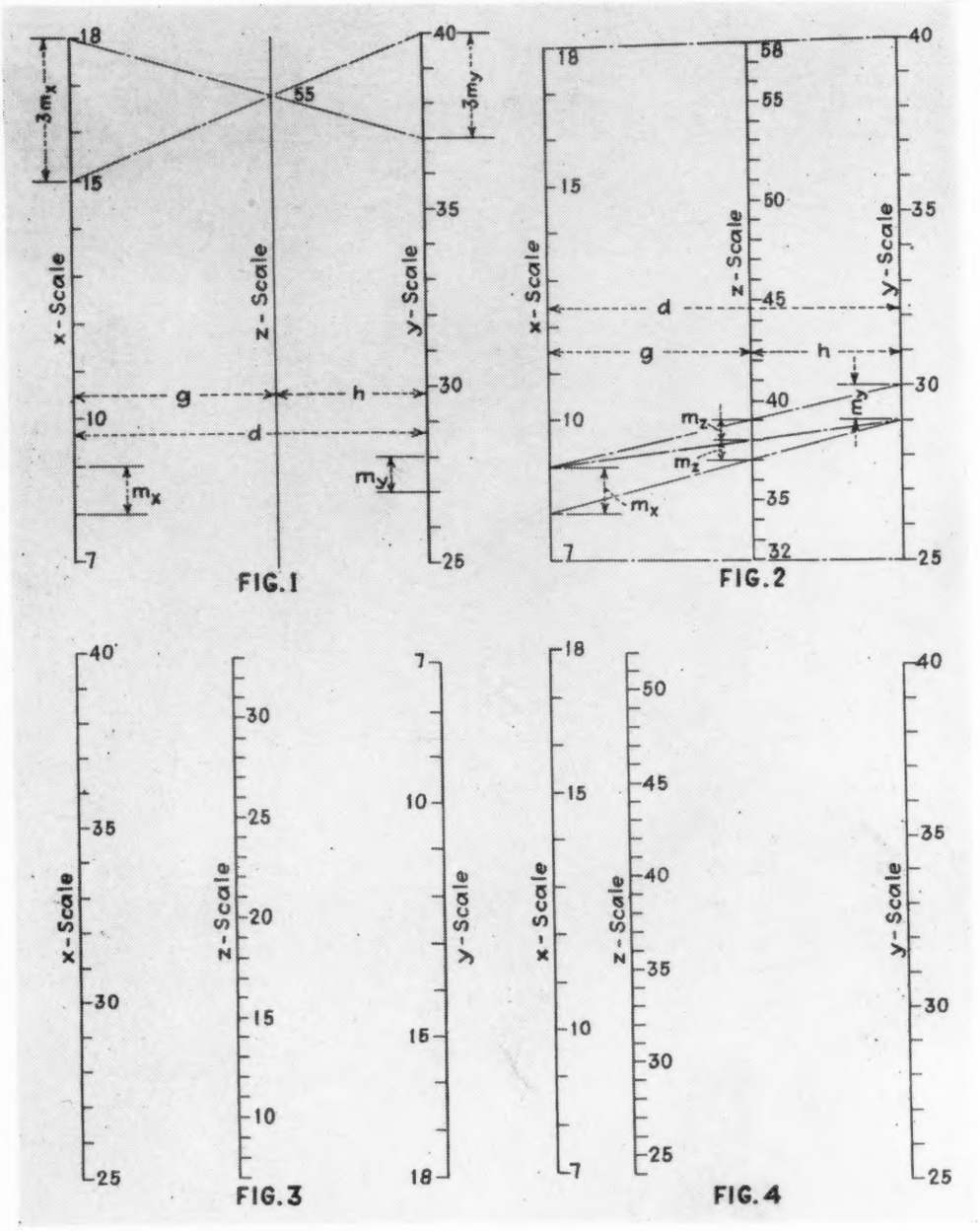
*Determination of the size of the z-scale units by the construction methods, and demonstrating the proof of the formula method*

**FIG. 3**

*The chart for x-y=z is the same as the one for x+y=z, except that the x and y scales ascend in opposite directions, with the x and z scales in the same direction*

**FIG. 4**

*Nomogram for the equation 2x+0.4y=z, illustrating the method used for the type equation ax+by=cz*




the $z$ scale will always represent the sum of any pair of connected points on the $x$ and $y$ scales. Referring to Fig. 1, it is obvious that a series of lines will intersect at a single point when these two conditions are met:

(a) When a series of straight lines are drawn across two parallel lines so that each intersection of one parallel line is constantly the same distance above the intersection with the preceding line.

(b) When each intersection on the second parallel line is always the same distance below the intersection with the preceding line.

Because such a series of lines can be started in any random position, the intersections of all such series will be found to lie in a third straight line which is parallel with the first two vertical lines, providing the same constant distances are used.

The above principles are used in the simplest nomograms. When parallel lines have a sequence of numbers assigned to equal subdivisions, it is possible to add or subtract, since every series of lines intersecting at a common point on the third parallel line represents a different sum or difference which can be indicated, as in Fig. 1, by a corresponding number.

To prove Equations (1) and (2) for the formula method, referring to Fig. 1, from similar triangles:

$$g/3m_x = h/3m_y$$

Here $g$ and $h$ are the altitudes of the two triangles shown. Therefore:

$$\frac{g}{h} = \frac{m_x}{m_y} \text{ and } \frac{g}{h} + 1 = \frac{m_x}{m_y} + 1$$

From which:

$$\frac{g+h}{h} = \frac{m_x + m_y}{m_y} = \frac{d}{h}$$

Solving this last equation for $h$ gives Equation (2) above. Substituting for $h$, its value $g\ m_y/m_x$ gives Equation (1) above.

In this demonstration $m$ is defined as the length of a single scale unit. However, it is possible to obtain greater accuracy by letting $m$ represent a multiple of units, 10 for example, for each variable involved.

SIZE OF THE *Z*-SCALE UNIT—This can be determined by a construction method or by a formula method. In the construction method, as shown in Fig. 2, draw horizontal lines between the upper end of the $x$ and $y$ scales and between the lower end of these scales. The corresponding value of $z$ for the top and bottom of the $z$ scale can then be determined from the equation $x + y = z$. This gives the numerical values at the top and at the bottom of the $z$ scale. Subdivide the $z$ scale uniformly between the upper and lower $z$ scale values.

FORMULA METHOD FOR DETERMINING THE *Z* SCALE—Referring to Fig. 2, from similar triangles, $m_x/d = m_z/h$ and $m_y/d = m_z/g$. This relates $m_z$ to the distance between the $x$ and $y$ scale lines, and from Equation (1) leads to the equation:

$$m_z = \frac{h}{d}m_x = \frac{g}{d}m_y = \frac{m_x m_y}{m_x + m_y}$$

Solving this equation with the known values of $m_x$ and $m_y$, as used on the $x$ and $y$ scales, respectively, the $z$ scale can be laid out. The starting point can be readily obtained, as shown in Fig. 1 and described previously.

It will be noticed that in the examples given, the distance between divisions is greater than would normally be selected for a chart designed for use. The object here is to show many simple figures rather than a few with great detail.

## *Nomogram for $x - y = z$*

The same procedure is followed for the equation $x - y = z$, as shown in Fig. 3, as was followed for the equation $x + y = z$, Fig. 1, with the exception that the $x$ and $y$ scales ascend in opposite directions. The $z$ scale ascends in the same direction as the $x$ scale, the equation represented being $x - y = z$.

## *Illustrative Examples*

To illustrate the construction of a chart $x + y = z$ with an actual example, assume the following ranges: $x = 7$ to 18 and $y = 25$ to 40. The limits of $z$ will then be 32 to 58, as determined from the relationship $x + y = z$. In Fig. 1, the equally divided $x$ scale of 11 divisions and the $y$ scale of 15 divisions are laid out on parallel lines, taking most advantage of the available space. Any value of $z$ can be used to locate the $z$ scale by construction. In Fig. 1, a value of $z = 55$ was selected. Among the numerous values of $x$ and $y$ that will satisfy the equations are $x = 18$ and $y = 37$; and $y = 40$ and $x = 15$ ($18 + 37 = 55 = 40 + 15$). Two intersecting lines through these values of $z$ and $y$ locate 55 on the $z$ scale and a line is then drawn through the intersection parallel to the $x$ and $y$ scales.

On the original nomogram for Fig. 1, drawn on 8½x11-in. paper, it was determined by measurement that $m_x = 0.806$ in., $m_y = 0.594$ in., and $d = 5.90$ in. With these figures and using Formula (1):

$$g = \frac{m_x}{m_x + m_y}d$$

Substituting the numerical values, this gives:

$$g = \frac{0.806 \times 5.90}{0.806 + 0.594} = 3.40 \text{ in.}$$

Measurements made over 10 subdivisions on each scale increase the accuracy of the determination.

Since $z$ varies through a range of 26 units, 26 uniform divisions are placed on the $z$ scale between the limiting lines drawn from $x = 18$ to $y = 40$ and from $x = 7$ to $y = 25$, as shown in Fig. 2. Or the length of these divisions can be determined by the formula:

$$m_z = \frac{m_x + m_y}{m_x + m_y} = \frac{0.806 \times 0.594}{0.806 + 0.594} = 0.3420$$

As stated above, the letter $m$ can represent multiples of 10 or more units, as well as a single unit, with resulting increased accuracy.

## *Nomogram for $ax \pm by = cz$*

The constants $a$, $b$, and $c$ may be ignored if the construction method is used. The procedure is then identical with that for the type equation $x \pm y = z$.

In the formula method, modifications allow for the constants. For the location of the $z$-scale line by the formula method, it can be shown by similar triangles, using the same method as shown in Fig. 2, that:

$$\frac{g}{d} = \frac{m_x/a}{m_x/a + m_y/b}$$

Then the size of the $z$-scale unit will be:

$$\frac{m_z}{c} = \frac{hm_x}{da} = \frac{gm_y}{db}$$

$$= \frac{(m_x/a)(m_y/b)}{m_x/a + m_y/b} = \frac{m_x m_y}{bm_x + am_y}$$

It is observed that the constant always accompanies the same variable that it does in the type equation. In other respects the formulas for location and size of the $z$ scale are identical with those for the equation $x + y = z$, as described above.

The procedure may readily be checked in Fig. 4, which is a nomogram for the equation $2x + 0.4y = z$, where the ranges of $x$ and $y$ are the same as in the previous examples.

## *Discussion*

As in the discussion of Fig. 2, the same principle holds true for the equation $ax + by = cz$, because the constants $a$, $b$ and $c$ affect only the numbering system of the subdivided scales. If $ax = u$, $by = v$, and $cz = w$, the equation reverts back to the simple form, $u + v = w$. The length of a unit of $y$ is $b$ times as long as a unit of $v$. This is evident from the following considerations. Assume that $b = 3$, then when $y = 5$, $v = 15$ and when $y = 6$, $v = 18$. Therefore, there are three units of $v$ in the same space as one unit of $y$, or, per unit, $y$ is three times as long.

However, to locate the scale line for $z$ which will apply to this particular equation, it is necessary to compute with lengths of the units of $u$, $v$ and $w$ which are equal to the lengths of units of $x$, $y$ and $z$ divided by $a$, $b$ and $c$, respectively. The variables $u$, $v$ and $w$ are really simple functions of $x$, $y$ and $z$ and the equation

could be treated as the more general function equation.

Throughout the remainder of this series of articles a symbol will be used to indicate a function of a variable. The use of functions enables simplications of formulas which would otherwise appear impossible to put into nomographic form. A function of $x$ is commonly written $f(x)$. Where different functions are used together, a subscript is used to differentiate between them; thus, $f_2(x)$ is not the same as $f_3(x)$, but $f_2(x)$ and $f_2(y)$ indicate the same function of $y$ as of $x$.

A function of $x$ contains the one variable, $x$, but can be combined with any number of constants. Some examples of functions of $x$ are $x^2$, $\log x$, $ax + b$, $x^2 + x - 5\cos^{-1}(1-x) - (1-x)\sqrt{2x-x^2}$.

## *Nomogram for $f_1(x) \pm f_2(y) = f_3(z)$*

The equations discussed thus far, illustrating the different types, have been special instances of the above function equation. The scale of the variable can now assume unlimited form, but the function scales remain uniformly divided. For example, if $f(x) = \log x$, the scale would be the familiar logarithmic scale; if $f(x) = x^2$, the scale of $x$ would be determined in the following manner.

Assuming that the limits of $x$ are 0 and 10, $f(x)$ will vary from 0 to 100 and the $f(x)$ scale will be uniform over this range. Values of $x$ from 1 to 10 would be placed opposite function values of 0, 1, 4, 9, 16 and up.

Logarithmic scales are usually longer than one complete cycle—which is, for example, from 1 to 10, 100 to 1,000, 47 to 470. Cycles of the same scale are the same length; the length from 1 to 10 is the same as from 10 to 100. A simple method for producing a logarithmic scale of any desired size is to acquire a stock of standard logarithmic graph paper of various sizes from which scales can be projected to intermediate sizes. Larger scales can be laid out on a uniformly divided scale from logarithmic tables.

It is obvious that the procedure of making a nomogram of function-scales is identical in every respect with the procedure for the simple formula, $x \pm y = z$. The replacement of function scales with scales of the variable as indicated above is the only additional step necessary to complete the nomogram.

The following example, illustrated in Fig. 5, will clarify the procedure. The strength factor for bevel gears is often determined by the empirical formula:

$$S = \frac{FY'}{P}\left(1 - M + \frac{M^2}{3}\right)$$

in which $M$ is a factor depending upon the relative number of teeth in the mating gears and two other factors $F$, $Y'$ and $P$ are all variables which, for the sake of simplicity, will be treated as a single variable $X$. The equation can then be written:

$$\text{Log } S = \log X + \log\left(1 - M + \frac{M^2}{3}\right)$$

Let the limits of $S$ be 0.1 to 0.65 and for $M$, 0.05 to 1.3. The limits of $X$ are 0.1 to 2.5. From these limits, the limits of the functions can be determined easily from a table of logarithms. Log $S$ varies from 9.00 — 10 to 9.813 — 10; log $(1 - M + M^2/3)$ varies from 9.978 — 10 to 9.420 — 10; and log $x$ varies between the limits of 9.000 — 10 and 0.398. Rewriting the equation in the following order:

$$\text{Log } S - \log(1 - M + M^2/3) = \log X$$

puts it into the standard form for placing the X scale between the other two scales.

If uniformly divided scales of the functions of $S$ and $M$ are laid out, as indicated in the procedure for the equation $x - y = z$, the result will be as indicated by the scales on the left side of the lines in Fig. 5. The location of the scale line for $X$ might be determined by selecting the value of $f(X) = \log X = 0$. Then when $f(S) = 9.800 - 10$, $f(M) = 9.800 - 10$ and when $f(S) = 9.500 - 10$, $f(M) = 9.500 - 10$. Two intersecting lines through these values of $f(S)$ and $f(M)$ locate 0 on the $f(X)$ scale and the latter scale line is then drawn through the intersection parallel to the two scale lines already drawn. In checking the formula method it is to be observed that the $f(M)$ scale has finer divisions than the $f(S)$ scale. Measurements over a group of fine subdivisions should be made, for example, from 9.48 to 9.98 for the $f(M)$ scale and from 9.0 to 9.5 for the $f(S)$ scale.

The size of the scale units of the $f(X)$ scale is dependent upon the size of the other two function-scale-units and the scale is laid out in the same manner as the $z$ scale previously described. At this stage there are three uniformly divided scales of the functions which are shown on the left sides of the three scale lines. The replacement of these scales with scales of $S$, $X$ and $M$ is the final step. A three place logarithmic table is all that is necessary in subdividing the strength factor and $x$ scales, but a calculation is required for every point or division line located for the $M$ scale. It is convenient to prepare a table of the division values desired on the unknown scale and the computed values of the function. The following table shows such values:

| $M$ | $f(M)$ | $M$ | $f(M)$ |
|---|---|---|---|
| 0.1 | 9.956—10 | 0.7 | 9.666—10 |
| 0.2 | 9.910 | 0.8 | 9.616 |
| 0.3 | 9.863 | 0.9 | 9.568 |
| 0.4 | 9.815 | 1.0 | 9.523 |
| 0.5 | 9.766 | 1.1 | 9.482 |
| 0.6 | 9.716 | 1.2 | 9.447 |
| ... | ..... | 1.3 | 9.420 |

Normally, the completed nomogram will have only the scale subdivisions shown in Fig. 5 on the right sides of the lines.

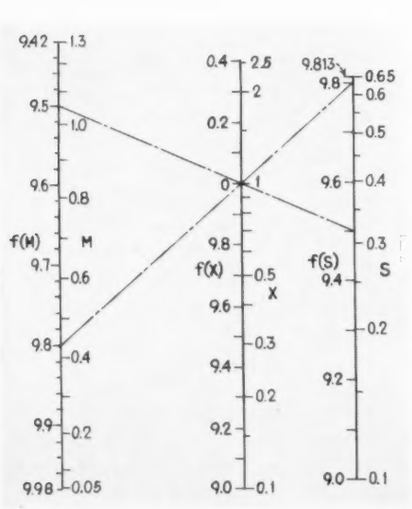
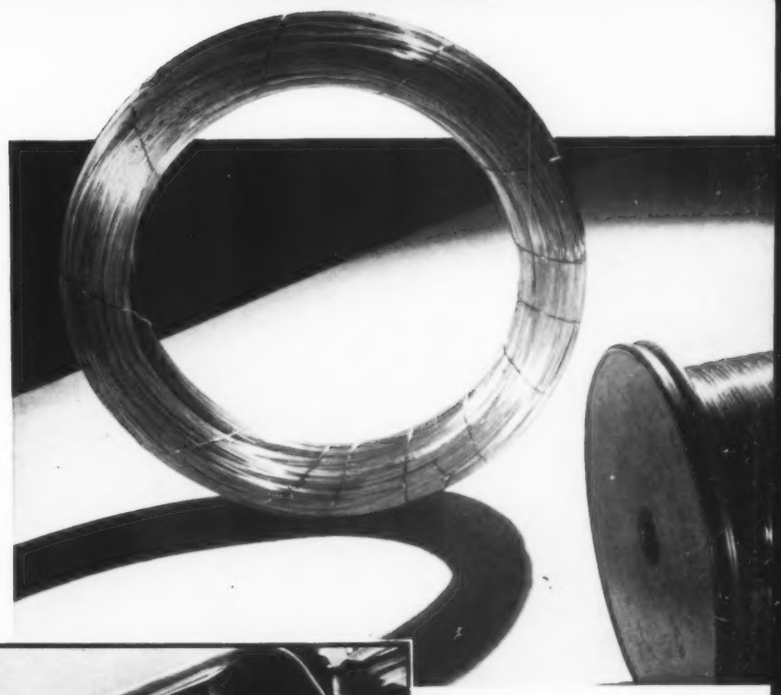


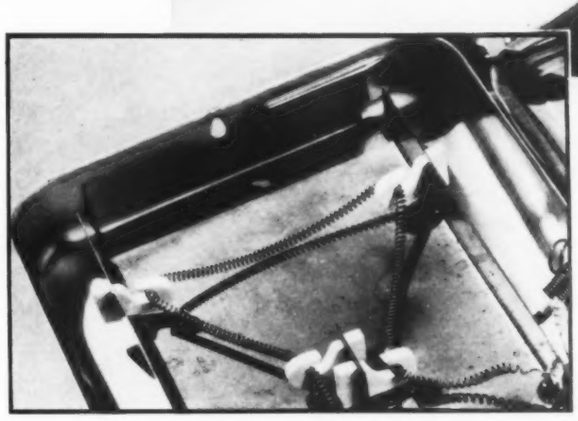

**FIG. 5**

*Illustrating the procedure for making an alignment chart for the equation of the strength factor S for bevel gears*

# How to Select Electric Heating Alloys

F. P. PETERS
*Chemist*
*Wilbur B. Driver Company*





*For the resistance alloys that sag, supports must be closely spaced to prevent grounding*

*Chemical composition, strength at high heat and electrical properties of each resistance alloy determines its field of application*

ELECTRICAL resistance alloys for heating service must have seven properties: high melting point, resistance to oxidation, low cost, resistance to growth, strength at elevated temperature, high electrical resistance, and low temperature coefficient of resistivity.

For a specific application, the melting point of the resistor material must be at least 300 deg. F. higher than the operating temperature of the element and at this temperature the material must have good resistance to oxidation and scaling. To be applied successfully to high-temperature service in air, the resistance alloy when hot must not form an oxide or must form an oxide of the protective type. If a material is selected that has a high melting point and good resistance to oxidation, heating elements will last months and often years at continuous or intermittent service.

Growth resulting in a permanent increase in length occurs in all resistance wires during long heating at high temperatures, and takes place even though the heating element is under no tension or load. The effect of sag on resistance wire is similar to growth, although the cause is different. A resistance wire will sag if its strength at high temperatures is insufficient to support its own weight. Sagging causes an increase in length during service, increasing the resistance, which decreases the wattage, and consequently reduces the operating temperature.

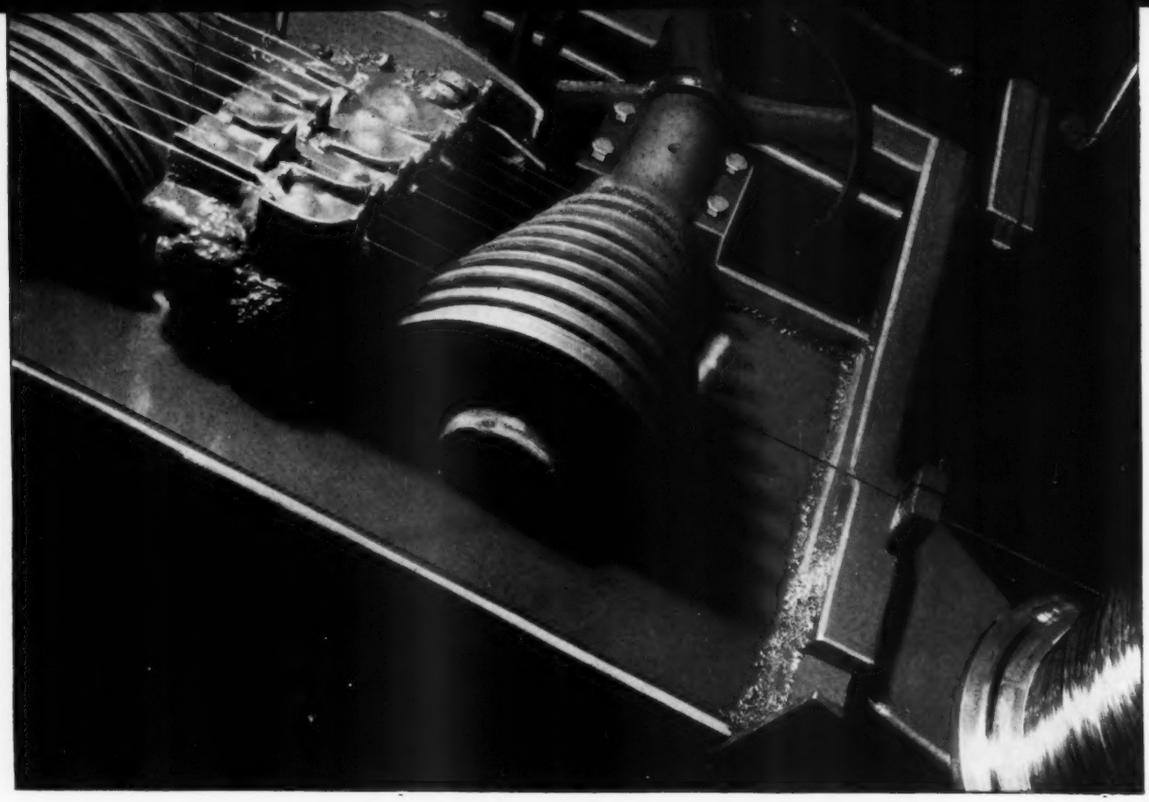
High resistivity, and a low temperature coefficient of electrical resistance are desirable. In addition to being low, the temperature coefficient should be constant over a wide temperature range. If the heater is wound for a safe current value when cold, the increase in resistance as the wire becomes hot reduces the current. With an alloy having a large increase in resistance with increasing temperature, the design of heating elements is difficult because both the final operating temperature and the electrical resistance depend on the amount of resistance increase.

Twelve of the most useful resistance materials are included in the accompanying table, with the composition and properties given for each alloy. In selecting the most suitable alloy for a given application the first consideration is the operating temperature. The resistance alloy must have a maximum operating temperature higher than the temperature required of the element wire. From the alloys that meet this requirement, the material that is least subject to growth and sagging is selected after taking into consideration such factors as cost, electrical convenience, and the quality of the appliance.

## *High-Temperature Alloys*

For operation in air at temperatures higher than 2,400 deg. F., the only suitable resistance material is one made of a precious metal or alloy such as platinum-rhodium. Platinum-rhodium and pure platinum do not oxidize at any temperature, the melting points are high, and these materials are but slightly subject to growth and sagging. On the other hand, these alloys are high in cost and do not have convenient electrical properties.

As shown by the table on the following page, the platinum alloys not only have low resistivity but also have a very high temperature coefficient of resistivity. Because of their low resistivity it is necessary to use low voltages on heating elements made of platinum or platinum alloys. Also, the high temperature coefficient of electrical resistance results in slow heating. However, the precious metal elements have a high resale or



*Resistance alloys are melted in induction furnaces, cast in small ingots and rolled into rod. By drawing through dies the wire is then reduced to the small sizes needed for resistance heaters*

*COMPOSITION AND PROPERTIES OF RESISTOR ALLOYS*

| Type and Composition | Resistivity Ohms per cir. mil. ft. | Temp. Coefficient per deg. F. (32-212° F) | Melting Point Deg. F. | Max. Operating Temp. Deg. F. | Growth at High Temp. | Strength at High Temp. | Relative Cost of Material |
|---|---|---|---|---|---|---|---|
| Molybdenum | 33 | 0.0022 | 4750 | 4000 (in $H_2$) | Slight | Good | Very High |
| Platinum | 72 | 0.0021 | 3110 | 2700 | Slight | Good | Very High |
| Platinum-Rhodium 80 Pt. 20 Rh | 125 | 0.00067 | 3260 | 2900 | Slight | High | Very High |
| Iron-Chromium-Aluminum-Cobalt 72 Fe, 20 Cr, 5 Al, 3 Co | 900 | 0.00003 | 3050 | 2350 | High | Poor | High |
| Iron-Chromium-Aluminum 68 Fe, 27 Cr, 5 Al | 850 | 0.00002 | 2770 | 2300 | High | Poor | High |
| Fecraloy 80 Fe, 15 Cr, 5 Al | 750 | 0.00005 | 2900 | 2100 | High | Poor | Low |
| Tophet A 80 Ni, 20 Cr | 650 | 0.00006 | 2535 | 2100 | Slight | High | Medium |
| Tophet C 60 Ni, 16 Cr, 24 Fe | 675 | 0.00007 | 2465 | 1830 | Slight | High | Medium |
| Tophet D 30 Ni, 20 Cr, 50 Fe | 600 | 0.00017 | 2550 | 1560 | Slight | Good | Low |
| Cupron 45 Ni, 55 Cu | 294 | 0.000006 | 2355 | 950 | Slight | Good | Low |
| Nickel-Steel 25 Ni, 75 Fe | 380 | 0.00067 | 2650 | 1100 | High | Fair | Low |
| Nickel-Silver 18 Ni, 60 Cu, 22 Zn | 190 | 0.00010 | 2030 | 850 | High | Poor | Low |

replacement value. For many applications between 2,100 and 2,400 deg. F., where low-cost alloys would otherwise be selected, platinum-rhodium is often used because of its longer life. Where the amount of heater material is small, reliability in operation may require the use of a platinum material.

## *Iron-Base Alloys*

For comparatively large heating units or those in which cost is a controlling factor, iron-chromium-aluminum or iron-chromium-aluminum-cobalt alloys are used for temperatures between 2,100 and 2,400 deg. F. These alloys have high electrical resistance and practically zero temperature coefficient, and also resist oxidation in this temperature range better than do the nickel chromium alloys.

Below 2,100 deg. F. the nickel-chromium alloys are not rapidly oxidized, and both growth and sag are less than for the iron-base alloys. In the temperature range from 2,100 to 1,000 deg. F., nickel-chromium and nickel-chromium-iron have high oxidation resistance, high resistivity and low temperature coefficient. They resist growth and sagging so well that they are preferable to iron-chromium-aluminum at operating temperatures for which both types are otherwise satisfactory.

Each of the nickel-chromium and nickel-chromium-iron alloys has a definte temperature range for which it is

most suitable. Alloys with 80 per cent nickel and 20 per cent chromium may be used at temperatures up to 2,100 deg. F. Below 1,800 deg. F. alloys of composition similar to 60 per cent nickel, 15 per cent chromium, remainder iron, are used instead of the higher cost nickel-chromium alloy for elements in which long life is not required. For inexpensive elements operating below 1,600 deg. F., a new alloy consisting of 30 per cent nickel, 20 per cent chromium, remainder iron, has been developed. Although not so durable as alloys was higher nickel content, the new material designated as "Tophet D" in the table meets the requirements of light duty at low cost.

None of the alloys below "Tophet D" in the table can be used successfully in air above 1,000 deg. F. But, for low temperature applications, the heating element usually outlasts other parts of the appliance, hence the resistance wire may be of a cheaper and less durable material. Cupron is a better choice than nickel steel and usually is better than nickel silver. However, to provide the longest life possible, high quality appliances are often designed with nickel-chromium or nickel-chromium-iron resistance wire even for low temperature service.

## *Molybdenum Elements*

For highest temperatures, molybdenum is used as a heating element material because of its extremely high melting point. This material is suitable for temperatures as high as 4,000 deg. F., well beyond the serviceable range of the platinum metals. In such applications, however, the resistor must be in a vacuum or surrounded by a protecting atmosphere of hydrogen or illuminating gas, because above 700 deg. F. molybdenum oxidizes in air. The oxide is volatile, and its evaporation leaves the surface of the wire exposed to further attack.

By means of standard life tests the performance of an alloy at a specific temperature can be forecasted accurately. The best standard life test in use today is one developed by the American Society for Testing Materials. This test is described in "Accelerated Life Test for Metallic Materials for Electrical Heating," in the *A.S.T.M. Standards* for 1933, page 877. After a 24-hour temperature adjustment period, test specimens are heated by a constant voltage, applied intermittently for 2 min. on-and-off periods. Alloys are rated in terms of "useful life" or the elapsed time resulting in a 10 per cent increase in resistance, and "life to burnout" or the elapsed time to rupture of the specimen. With some resistance wires, the useful life is as long as the life to burnout—that is, the resistance of the wire when it burns out is less than 110 per cent of its original value. With other alloys, the useful life is expended long before the wire is actually ruptured, and in such cases, the useful life is the more important measure of service life.

## *Failure from Growth*

In the iron-chromium-aluminum and the iron-chromium-aluinum-cobalt materials, the 10 per cent increase in resistance occurs before failure because of the high rate of growth. The burnout point for these alloys is of little importance, since the increase in resistance results in a decrease in current and a temperature as much as 200 deg. F., lower than the original temperature of the wire. Nickel-chromium, on the other hand, will show a useful life almost as long as the life to burnout. At temperatures near 2,000 deg. F. the useful life of an iron-chromium-aluminum or an iron-chromium-aluminum-cobalt alloy is no greater than that of available nickel-chromium alloys. For most applications where element temperatures are between 2,100 deg. F. and 1,000 deg. F. nickel-chromium or nickel-chromium-iron will be most suitable because of longer life.

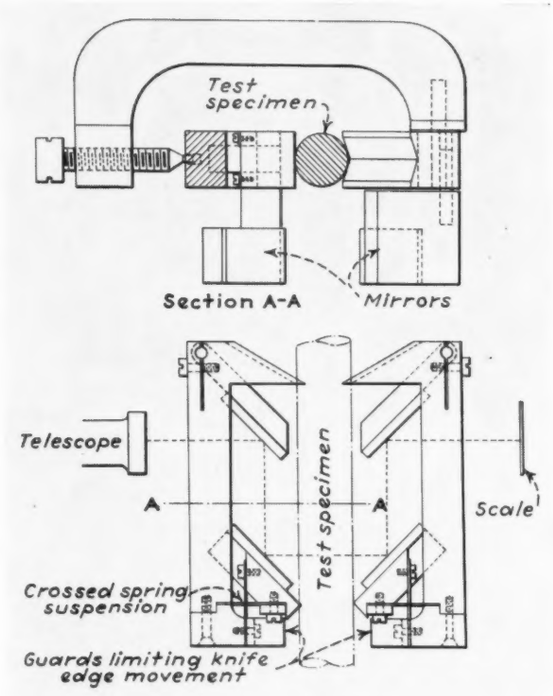
No resistance material is universally applicable, and for each individual application there is usually one alloy that is the most suitable. To avoid misapplication in any case, the design engineer should consult the alloy manufacturer, who may be in a position not only to select the proper alloy, but to assist in designing the heating element.

*Since the electrical resistance depends on both the composition and the wire diameter, each spool must be inspected and tested for electrical properties as well as wire diameter*

# QUESTION AND COMMENT

## *Mirror Extensometer Magnification*

*Magnification ratios can be accurately calculated with this modified form of mirror extensometer*




*To the Editor:*

● The computation of the distance from the mirror to the drum of a Marten's extensometer for a magnification of one thousand, requires more data than is given in the article by W. W. Mohr on page 469 in the December number. The distance is dependent on the angle which the mirrors make with the vertical.

An expression which gives the required distance $X$ with only a small errors is,

$$X = \frac{175 - 4.969}{6 \cos \theta}$$

In this relation $\theta$ is the angle of inclination of the mirrors with the vertical. The exact expression is much more complicated. —L. G. HALL
*Allegan, Mich.*

*To the Editor:*

● The magnification ratio of the compound Martens mirror extensometer described by W. W. Mohr in the December number is given by the following relation in terms of $D$, the scale reading on the drum.

$$D = \frac{2Xe_r}{0.175} + \frac{2(X + 2.4844)}{0.175} e_l$$

In this relation $e_r$ is the actual elongation between gage points on the right side of the specimen, and $e_l$ is the corresponding value for the left side. If both elongations are nearly alike, the mean elongation $e_m$ may be used in the following approximation,

$$D = \frac{4(X + 1.2422)}{0.175} e_m$$

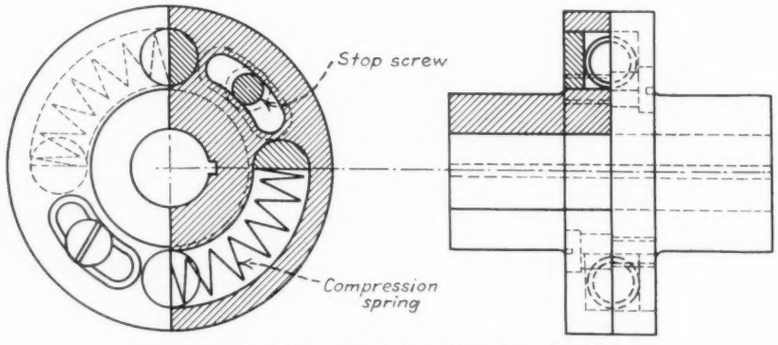
For a magnification ratio of 1,000 to 1 between elongation and scale reading, the distance $X$ must equal 42.51 in. for the extensometer described by Mr. Mohr.

This relation is correct only if the Martens lozenges are placed properly, with their axes essentially perpendicular to the length of the test bar. If the lozenges are tilted so that their axes remain perpendicular to the mirrors, as in Mr. Mohr's sketch, the magnification ratio will be dependent upon the exact angular position.

A modified form of mirror extensometer, shown in the accompanying diagram, was described by the writer before the American Society for Testing Materials in June, 1926 (*Proc. A.S.T.M.* Vol. 26, pt. 2, page 660). This paper also contains a complete derivation of the equations given above. —M. F. SAYRE
*Union College, Schenectady, N. Y.*

## *Errata*

● In the reference book sheet appearing on page 439 in the November number, "Stress in a Rotating Disk," the multiplying constant in the stress equation should have been $10^{-6}$ instead of $10^{-9}$ as printed. The chart itself is laid out correctly.




*Stop screws limit relative rotation allowing soft springs to be used in this coupling*

## *Floating Coupling for Torsional Vibrations*

J. A. HONEGGER
*New York, N. Y.*

● For drives requiring greater rotational freedom than is obtained from the usual flexible coupling, compression springs can be used to absorb torque pulsations or torsional shocks.

In the compression spring coupling shown in the accompanying diagram, relative movement between the two halves is limited by stop pins. When

used with soft springs, these pins take the drive in starting, and limit the stresses imposed on the spring.

## *New Use for Transparent Plastics*

*To the Editor:*

● In the design of a machine equipped with a molded plastic housing, after the sample machine was made it was found that one part was sticking when the machine was put in operation. Unfortunately, the machine could not be operated without the housing being complete. Investigation failed to reveal the part that was sticking or where the trouble was. To solve the situation a molded plastic housing was made of a transparent molding material. This enabled the engineers to see the internal functioning of the machine and the defect was discovered quickly.

—R. J. THOMPSON
*New York, N. Y.*

## *Alignment Chart for Engine Horsepower*

*To the Editor:*

● In the engine horsepower chart on page 320 in the August number, several calculations are required that could readily be incorporated in an alignment chart. The quantity represented by the rays is proportional to the torque $T$ and must be calculated from the bore $d$, the stroke $l$, the number of cylinders $c$ and the mean effective pressure $p$, using the relation,

$$T = 0.7854\, d^2lcp$$

Unless the displacement is given, this is a formidable calculation to make just for one of the variables. Even with the displacement given, utility of the chart would be improved by showing a scale for the rays rather than drawing in selected rays. With only a few guiding rays drawn in, any desired one could then be added by the use of the scale. The article "Charts Simplified by Using Distorted Coordinates," in the December number, shows how the ray scales can be drawn in.

To avoid the necessity for calculating the displacement, the engine horsepower chart can be made in the form of a double square nomogram shown here. This chart makes all the calculations by the use of two pairs of crossed lines. The right-hand square gives the engine displacement on the turning scale in the center. When the displacement is given, only the left hand square is used.—CARL P. NACHOD
*Louisville, Ky.*

## *Styling Costs*

*To the Editor:*

● Styling when used to increase the sale of machinery does not enhance the performance. As explained in "Seven Rules for Good Appearance," in the December number, the general appearance of a machine is an asset, but many times a cheap and inferior product is redesigned with pretty lines.

The man who buys a machine tool wants to get value for his money and knows that he has to pay for all the fancy work that accompanies the machine. All the fluting and ribbing that is used by the industrial designer to dress up the product adds pattern expense. Molding is made more difficult and thereby more expensive. To make a profit on such a machine tool, the manufacturer must include the cost of industrial styling in the price of the machine.

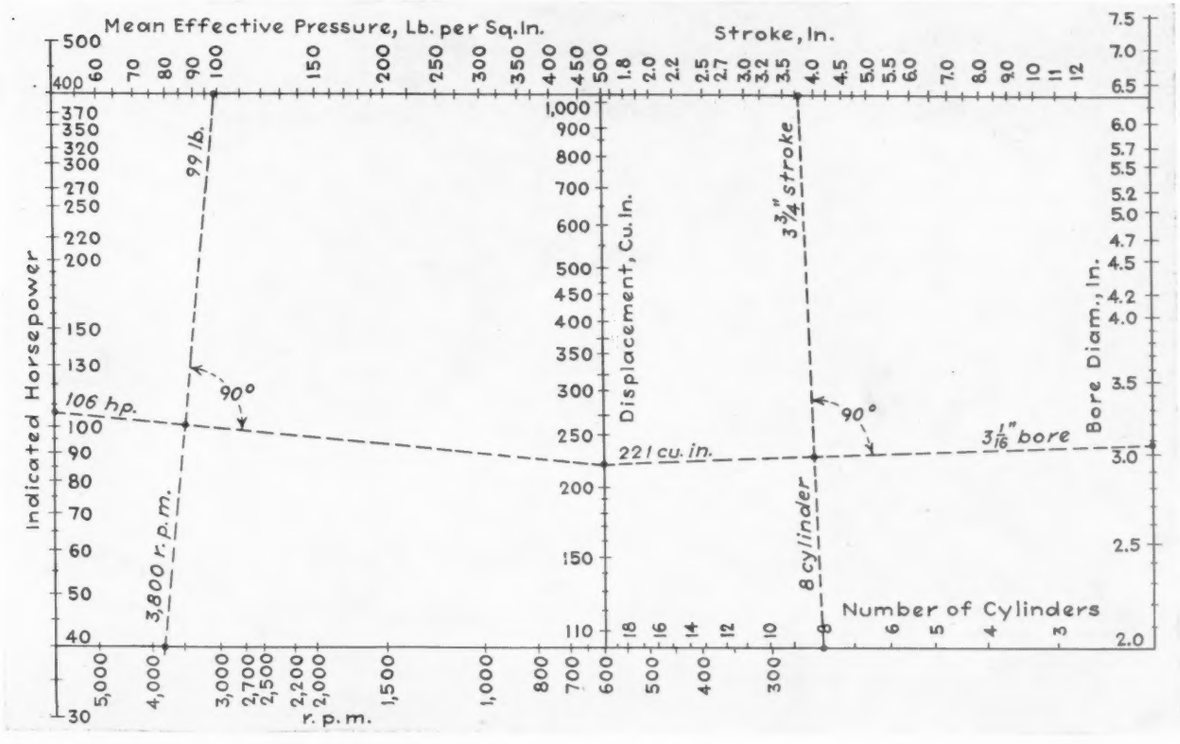
—R. J. PALMER
*New York, N. Y.*

## *Pinion Centers for Planetary Gears*

W. SPENCER
*Gardner-Denver Company*

● The usual train of planetary gearing consists of a sun gear, an internal or ring gear and a planetary gear. More than one planetary gear may be used and they are usually placed sym-

*A double square nomogram giving piston displacement in the right-hand square and engine horsepower in the left-hand square*



metrically around the sun gear. Where even ratios are desired such as in the design shown in Fig. 1, with an 18-tooth sun gear, three 18-tooth planetary gears and a 54-tooth ring gear, the planetary gears will mesh 120 deg. apart. Where there is no interference, they will mesh every 10 deg. as at 80 deg., 90 deg., or 100 deg., from the center line.

When a special ratio is required, such as an 18-tooth sun gear, three 19-tooth planetary gears and a 56-tooth

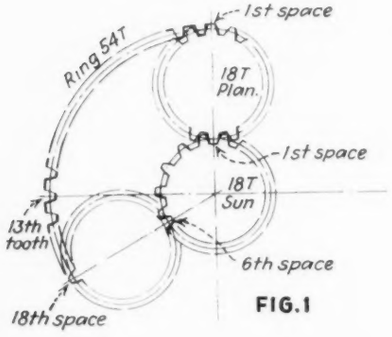


FIG.1

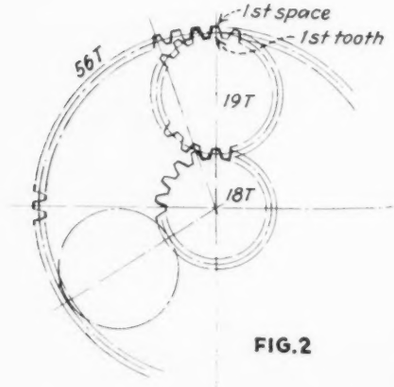


FIG.2

*Fig. 1—Meshing point of the planetary gear depends on the tooth combination. In Fig. 2 the angle is 123.16 deg.*

ring gear, as shown in Fig. 2, the gears may not mesh when placed 120 deg. apart.

In the design shown in Fig. 2, the 6th tooth of the 18-tooth sun gear is radially in line with a point $18\frac{3}{4}$ teeth from the center line on the ring gear, and the planetary gears cannot be placed in mesh unless the number of teeth is a whole number.

To find the correct angle assume that one of the planetary gears is placed on the center line with the teeth bisected as shown. Now assume that the ring and sun gears are clamped rigidly in place. Then, imagine the planetary gear withdrawn from the ring gear but remaining in mesh with the sungear. If the planetary gear is revolved slowly to the left, its teeth pass over those of the ring gear and the sun and planetary gears will remain in mesh. Therefore only the ring gear needs to be considered.

When a radial line passing through the centers of sun and planetary gears moves through one tooth space on the sun and planetary gears where they mesh, the line will also pass through one tooth space on the outer edge of the planetary gear. However, 3 1/9 tooth spaces will be passed on the ring gear.

Again, when the radial line passes one tooth on the ring gear it passes only 18/56 of a tooth on the planetary gear. Therefore these gears cannot mesh until after one whole tooth has been passed on the ring gear and until the radial line coincides with the same fractional portion of tooth on both planetary and ring gears.

Then distance $d$ that the radial line moves over ring gear, in terms of the fractional tooth $x$, is

$$d = 1 + x = \frac{56}{18} x$$

Expressing this relation in general terms where $N_s$ is the number of teeth in sun gear and $N_r$ is the number of teeth in ring gear.

$$1 + x = x\ N_r / N_s$$

$$x = \frac{N_s}{N_r - N_s}$$

The angular distance $\theta$ in degrees between meshing points is,

$$\theta = \frac{360\ x}{N_s} = \frac{360\ x\ N_s}{N_s (N_r - N_s)}$$

$$= \frac{360}{N_r - N_s}$$

For the design shown in Fig. 2, the angular distance required for the gears to mesh is,

$$\theta = \frac{360}{56 - 18} = 9.47 \text{ deg.}$$

The point nearest to 120 deg. is $9.4737 \times 13$ or 123.16 deg. for this example.

# *Scale Illumination*

GEORGE H. GROCOTT
*Toledo Scale Company*

● A mechanism within the Toledo Printweigh scale automatically stamps the weight on a paper tape, but a visual indication of the weight is also needed to show the scale operator that the indicator has come to rest before the printing operation is performed. For convenience the large scale pointer and stationary dial is replaced by a stationary pointer or index line before a rotating chart made of aluminum alloy. Thus, as shown in Fig. 1, the weight is always read at one point directly in front of the operator.

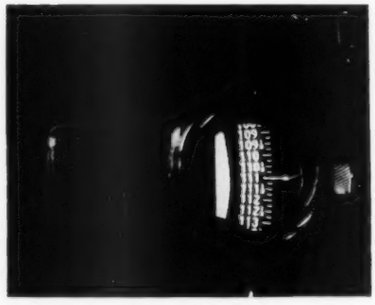


*Fig. 1—Rotating chart and stationary index in the Toledo Printweigh scale are illuminated for easy reading*

For accurate reading at least 300 scale divisions are needed but the limited chart diameter makes it necessary to use small figures. In order to make these small numbers easily read, a magnifying lens shown in Fig. 2 is built into the scale. A small lamp inclosed in the housing throws high-intensity light over the reading area, while a metal reflector between the lamp and the lens prevents glare and also directs light against the chart. Figures and index lines are highly polished to offer maximum contrast with the black background.

To keep the raised chart figures clean, the record tape is placed between the inked ribbon and the chart. Pressure for printing is then placed against the ribbon.

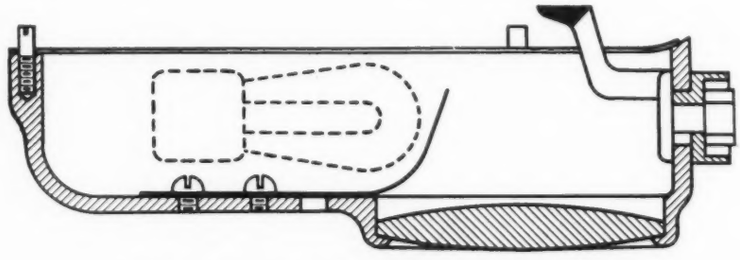


*Fig. 2—Magnifying lens and shielded lamp allow the use of a larger number of chart figures*

# COLOR ILLUSIONS

HOWARD KETCHAM
*Color Engineer*

*Color circuit divided into fifty hues. Colors opposite each other give true contrasts; neighboring colors harmonize*

**Success in color selection requires a knowledge of the subjective differences between colors. In this article the author explains the essentials for pleasing color combinations and shows how color illusions enter into the problem**

COLORS have no subtle meaning in themselves. It is their relation to other colors, their unconscious association with events which gives them meaning. It is the appeal of color—the effect that it has upon the public—which gives the color sales force. To understand this appeal, it is necessary to understand the underlying rudiments of color, so that the handling of them can be effected.

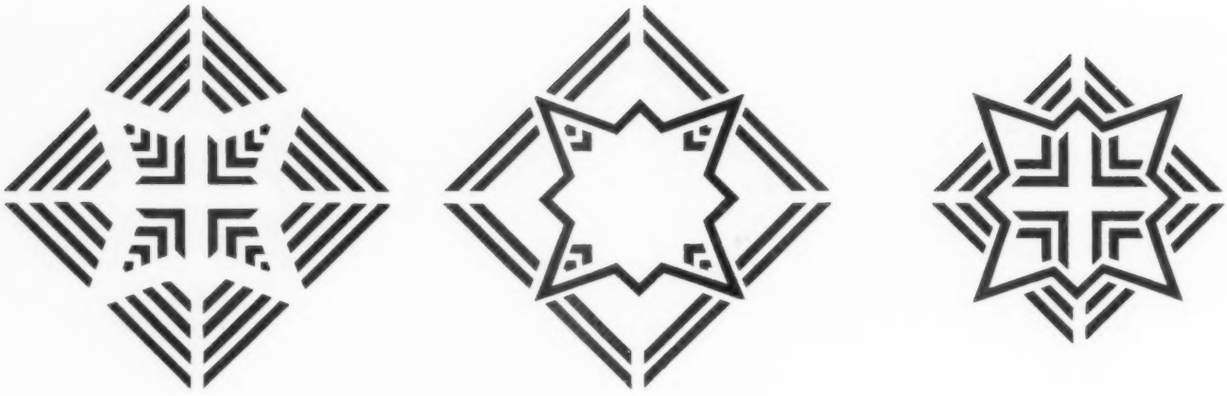
Subjectively, color can be defined as a property of the eye itself. Thus defined, it is a specific response to certain wave lengths and intensities. The source of all color is light. The illusion which we call color is the interpretation which the reflective or absorptive quality of an object's surface imparts to the senses through the intricate functioning of the eye.

The best objective definition of color is that definition by which the late Albert H. Munsell, the great color scientist, made it possible to define the appearance of a color in notations as exact as the height, width and length of a cube. Mr. Munsell called his dimensions hue, value and chroma. Hue is the attribute of a color by virtue of which the normal eye perceives it as differing from another color family. Red is a different hue from blue. Value is that attribute of a color by virtue of which the normal eye perceives it as holding a position in a light to dark scale. Chroma is that attribute of a color by virtue of which the normal eye perceives in addition to hue, the presence or absence of grey. Any green, for instance, is green in hue. A high value is a tint and a low value is a shade. An olive green is a color of weak chroma, while an emerald green is a green of strong or powerful chroma.

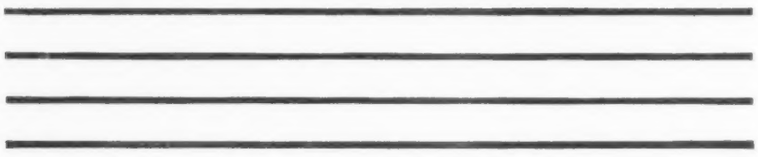
With simple notations, universally used, we would have color standards impervious to changing fashions in color.

The importance of fully establishing this simple definition of color is greater than people think. If stylists universally adopted notations for colors, as musicians do for music, we would have accurate objective terminology both in art and industry. This would replace the present day faulty and emotional color phraseology which relies on the variable subjective human reactions.

But the great problem in colors is not what they are



*E. I. DuPont de Nemours & Co., Inc.* ©



*In these three figures, the yellow, blue and red stars respectively, stand out most because they present an unbroken line of color*

*The white hairlines cause the yellow-red stripe to look bluish, and weakens the chroma of the yellow*

in themselves so much as what relation they have to each other. A knowledge of this second principle enables one to combine colors so that they appear to best advantage. It is a curious fact that the same colors appear pleasant in a particular order of strength and unpleasant when in the opposite order. A full, rich yellow next to a deeper orange, will look well, but if the same yellow be used with lighter orange, the result will be unpleasant. One of the new color combinations, blue and green, is harmonious when these two hues are used together in the proper order of strength. A high value, strong chroma variation of green of maximum hue—strength 5 green 55, (Munsell notations) for example, placed beside a darker blue looks well. The same green, however, if used with a blue of higher value—that is, lighter, will produce a discordant color arrangement. Perhaps the thought of this latter combination deters many people from using blue and green together.

Thus, the proper order of strength is necessary to assure color harmony. We can discern the apparent function of the natural grouping of colors in nature. Toward the close of day, the sun changes in hue from yellow to orange, from orange to red, from red to crimson, and from crimson to purple, the yellow being the highest and the purple the lowest value. Appealing two and three hue arrangements can be derived from color groupings carried out in accordance with nature's law of color.

By keeping to this order, anyone can produce creditable color sequences. In this particular order of arrangement, colors look rich, limpid and harmonious. In the reverse order, one color invariably looks washed-out, and the other muddy or dirty.

Certain colors tend to intensify and enliven each other. Groupings of colors that produce this effect are called contrasts. There are only five ways in which color contrast can be achieved:

1. Use a color with its complement—for examples, use blue with yellow-red; yellow with purple-blue; red with blue-green; green with red-purple; or purple with green-yellow.

2. Use a high value color with a low value color.

3. Use a strong chroma (pure) color with a weak chroma (greyed) color.

4. Use a warm color with a cold color. A warm color contains either red or yellow. A cold color contains blue. Pure green is the spectral intermediary. When it is yellowish, green is warm; when bluish, green is cold.

5. Use a large area of one color with a small area of another color.

Contrasting colors are those which, when placed side by side, intensify each other, but do not change. Colors which are not contrasts tend to change their appearance when placed side by side. When red is placed beside yellow, it looks bluish and the adjacent yellow inclines toward green.

Another optical modification to color is that which affects the contrast of value or the intensity of color. A light red beside a darker value of yellow will tinge the yellow field with a greenish hue and heighten the value of the yellow. Also, the red will be made to appear darker in value and bluer in hue. A dark field makes an adjacent color appear lighter and a light field makes the same adjacent color appear darker. Two adjacent colored areas can influence each other in such a way that when viewed at the same time, they appear different in hue, value and chroma than they do when seen separately.

Similarly, the use of a white hairline on either side of a stripe of color introduces the complementary color into the hue of the stripe color and weakens the chroma of the background color. In the accompanying illustration, the yellow-red stripe looks bluish where it is edged with white, blue being complementary to orange. White and black are both splendid foils for color. They refresh the eye, enabling it to find neighboring colors

brighter, thereby exaggerating the importance of each color and so harmonizing it with its neighbors. The Union Jack owes much of its brilliance to the presence of white among the reds and blues. "White harmonizes all things." On the other hand, black outlines colors, making them deeper or, technically speaking, lower in value and stronger in chroma. That is why leaded windows in cathedrals have a jewel-like quality. By the use of black and white, you can make your color deficiencies your assets. A weak spot of color can be given importance by the simple use of black and white.

By dividing a circle into the proportion of the colors of the spectrum, as in the headpiece of this article, and by taking the hues in pairs as they stand opposite one another around the circle, a series of true contrasts can be had. Harmony, on the other hand, is the effect produced by using any color with its next neighbor or neighbors in the circle in their natural order—as shown in the sunset. As many as six colors can be combined in this manner without fear of creating d i s c o r d s. Astonishingly enough, discords, or the reversal of the natural order of colors, can be used in small quantities to add to brilliance. They remove the cloying effect of too much smoothness, just as in music. The unexpected has always a certain charm—as seen in the uses of discord found in Japanese art.

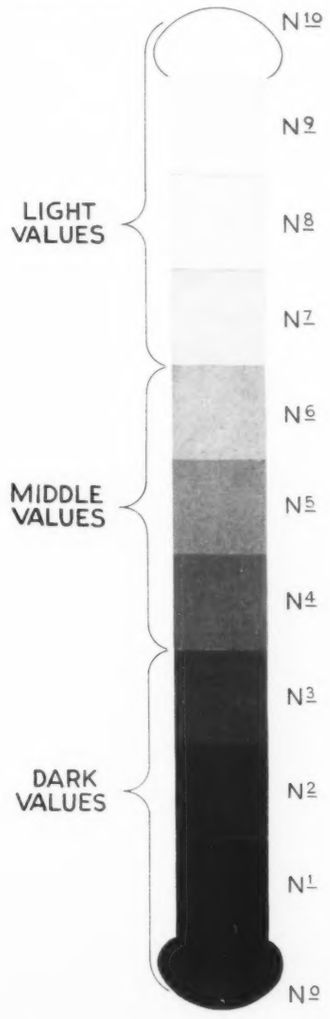
Quantity of color has effect just as quality has. Two large areas of color placed together have an altogether different aspect than the same two colors grouped in narrow alternate stripes. This is the fifth principle of color contrast in our list. Wide stripes of contrasting color, placed adjacent to one another, are disagreeable looking. The usual procedure for promoting harmony is to mix a bit of one color into the other and vice versa. This affords an improvement, but at the expense of brilliance. Brilliance, however, may be maintained by alternating fine lines of bright contrasting colors. The disagreeable influence of one color upon another can be easily overcome by adding a proper quantity of the color causing the injury to the injured color.

Continuity of color sometimes has more effect in treatment than either the actual amount of color used or the value and chroma of the particular hue. Take, for example, the three accompanying pictures of the concentric squares with the superimposed stars. In the first square, the yellow stands out from its blue and red background. Yet, actually, red is a more advancing color than yellow and, in this particular case, there is much more red present than yellow. The yellow stands out because its line is unbroken. In the second example, with the same three colors used, it is the blue which possesses continuity of line and therefore it is the blue that stands out. In the third square, it is the red. Thus, the single unbroken line of color is most prominent in each of these three illustrations.

In addition to the influences that other colors have upon combinations, there are other external and greatly varying factors to be taken into consideration when undertaking the effective combining of colors. One of these outside influences comes from ourselves—the structural formation of our eyes. When we look at a strong chroma color for a sufficient length of time, a partial exhaustion of the visual process results and we tend to see an after-image in the form of the color's complement. This fact can be practically demonstrated by looking at the three colored disks pictured on the next page. Stare at the central black dot so as to include all three colored disks in the field of vision. After about 15 seconds turn the eye to the black dot surrounded by white. You will see an after-image of the red in the form of a blue-green circle, the yellow will appear as purple and the blue as orange. It is thought that this reaction occurs because the components of white light are red, green and blue, and that when the eye can no longer respond to red, through fatigue, the resultant after-image is blue-green. Successive experiments with other colors will indicate that the complement of orange is blue; that of yellow is purple-blue; that of purple is green-yellow.

This principle can be turned to practical application by using complementary colors to enhance each other through reciprocal contrast. A red stripe on a blue-green car body imparts added vigor to the blue-green. Blue-green, in turn, through its nega-

*Gradations of value from black to white, according to the Munsell system of color designation*




*E. I. DuPont de Nemours & Co., Inc.*

*White between the red and the blue of the Union Jack adds much brilliance. Black between the red and blue makes them lower in value and stronger in chroma*

tive after-image imparts added vigor to the red. Color contrasts of this kind are always most effective where the value and chroma strength of the complementary colors used is equal.

Any color that subjects the eye to colors of unbalanced vibrational intensity is harmful. A group of Canadian mechanics engaged in applying the priming coat on structural steel towers, complained that their eyes smarted until the tears came and their heads ached. They blamed the volatile paint thinner for their discomfort. But when they were shown how to mix a sufficient quantity of carbon black to weaken the chroma strength of the red, their discomfort ceased.

Another external stimulant to color combination is sunshine. In regions where there is little sunshine, colors look garish and blatant which would appear in excellent taste in hot sunny climates—such as Florida or California. That is because strong sunlight is a harmonizing agent. Hence, bright colored automobiles sell best in California.

It is clear that combinations of color can be used to convey, skillfully, certain appearance impressions through optical reactions. It is important, in most professions to have a good knowledge of color and color combination. The dental profession is perhaps the best practical example of this. Complexion colors must be protected by color artistry in dentistry. The minute but noticeable differences required for matching purposes in this profession are today produced by color measurements, determined with the aid of the Munsell color system.

The psychological effects of color and, through them, the control of public response should be even more important to the business man than the matching and combining of colors as an art in itself.

Color can be used to subtly influence judgments. It produces an effect upon size. Objects that are colored in strong chromas of high values appear to be larger than objects of exactly the same dimensions which are finished in colors of darker value. Rooms finished in high value colors appear larger and more spacious-looking than rooms finished in low value colors. Color also produces an effect upon apparent weight. The tendency is to judge yellow-red (orange), red or black objects as being heavier than objects of equal weight finished in yellow, blue or green.

These psychological uses of color partially explain why certain colors attract the public and certain colors repel them. There is no positive explanation why certain colors sell and others do not sell. Perhaps it is the effect of those unnoticed childhood experiences which are said to cause so many of our eccentricities. Perhaps it is the habitual association of certain colors with specific events. Perhaps it is local associations which have become connected with given colors. The reaction to color is a local affair. Different colors sell in different parts of the country, at different seasons of the year—and there is an unexpected transience in color tastes. Just as the manufacturer thinks he has the market analyzed, the market decides it no longer wants that variation of color. It is this that makes the practical application of color knowledge a complicated problem. The problem requires not only expert knowledge, but also an open mind. What is the puzzled manufacturer to do? Just this—be guided by the public—listen to its dictates. Don't attempt to dictate to it. It is not economical to experiment with finished products.

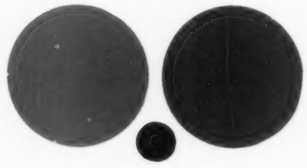
The manufacturer who wishes to expand his market must time the pulse of the public through constant survey. Through survey, it was found by the duPont Viscoloid Company that lilac would sell best in dresser sets. Although a revolutionary color, lilac sold out completely before the large Christmas selling season arrived. Similarly, a certain green has been found to sell best in fountain pens. Black has been found the best color for automobiles in metropolitan areas. Red has been found the best color for toy trains. Jewelry has been found to sell best in purple and yellow containers of strong chrome; and perfume to sell best in the same color containers of weak chroma. Each object, each product, has its most appealing color. It remains to find it!

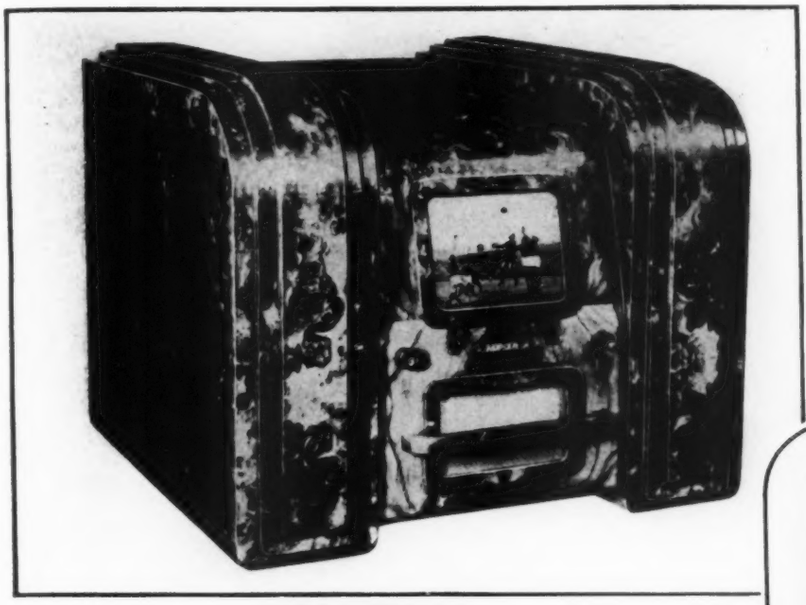
There is direct evidence that many manufacturers have abandoned the old hit and miss method of color selection. There is in existence at least one company created to serve manufacturers in determining by actual surveys the public response to any color for any product in any price range in each of the leading market centers.

Knowledge of color's acceptance in the market and adequate knowledge of color within itself, both in terminology and combination, are the factors which create modern industrial color success. This is the direct result of a startling consciousness of color which has been manifested in the last few years as a new phase of sales approach. The demand for beauty applies not only to so-called fashion merchandise, such as gowns, hats and shoes. It applies to almost all articles, even those that formerly were considered merely the prosy and commonplace necessities of life, such as kitchen utensils and equipment. Today, bread boxes, kitchen cabinets, broom handles, dust pans and even tea kettles are being enlivened with a touch of color.

Perhaps all this explains why, in a period of general industrial standstill, color advertising has increased 4,000 per cent. Color means change and turnover and that is basic in any effort at industrial revival.

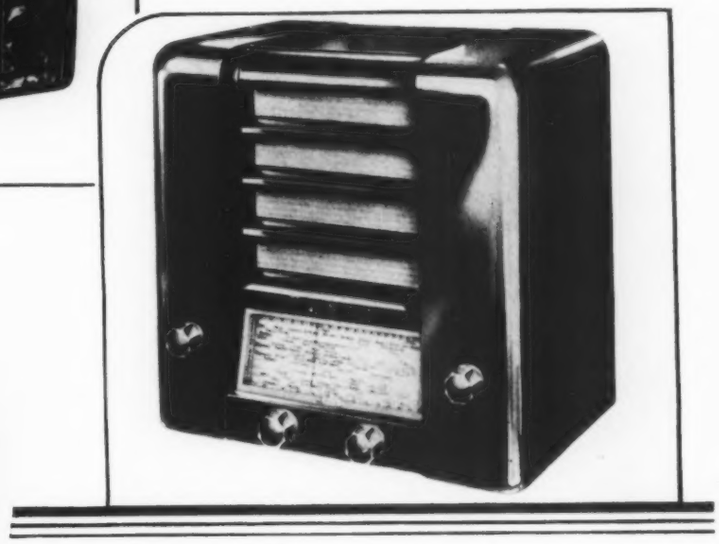
*Stare for about 15 seconds at the central black dot so as to include all three colors in the field of vision. Then look at the black dot below. After a few seconds, an after-image will appear on the blank paper; the red will appear as blue-green, the blue as orange, and the yellow as purple-blue*





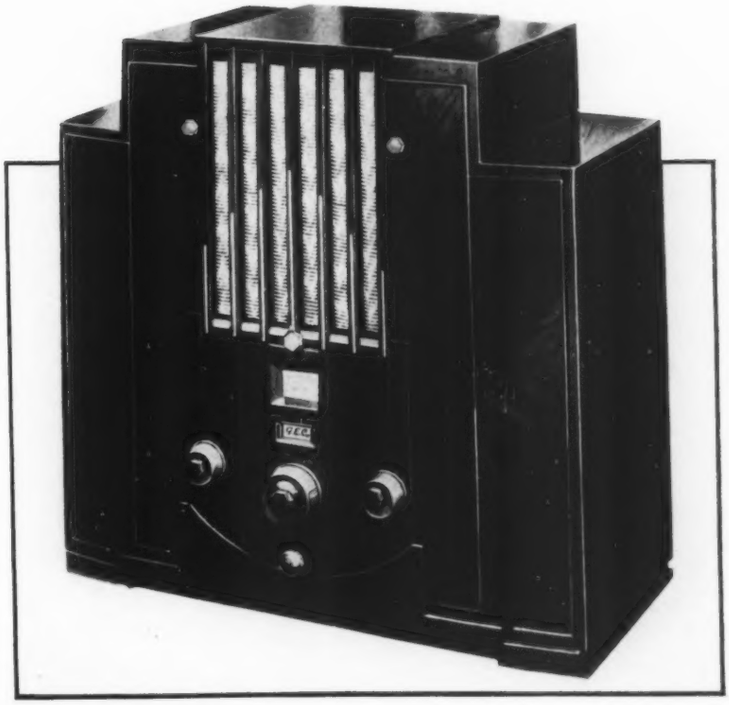
*Italian television receiver with plastic cabinet. Image, 8x10 in., is reproduced 25 frames per sec. Below the screen is the opening for the loudspeaker*

*Black molded plastic cabinet of German design, with loudspeaker screen and dial fittings in silver gray. Note the size and type of the tuning scale*



*Claimed to be the world's largest tuning scale, with both the names of the stations and the kilocycles appearing on the dial. An English design of molded plastic cabinet 15¾ in. in diameter, with chromium-plated fittings*

# *Foreign Radios in Plastics*



*Another English design of one-piece molded plastic radio cabinet. It is 13¼ in. high, 13½ in. wide and 7½ in. deep. It has a lustrous brown finish, relieved with lines of old-gold*

# *Typical Designs of*

CYRIL DONALDSON
*Rochester Mechanics Institute*

## In this first installment of a series of four articles, the designs shown use rubber or springs for the flexible element

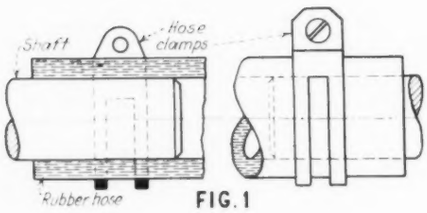


FIG. 1

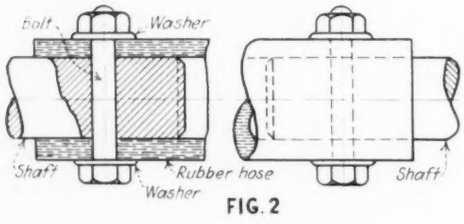


FIG. 2

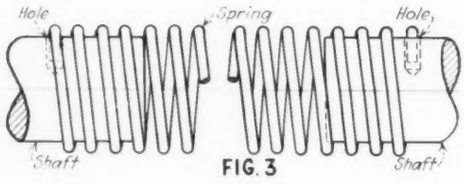


FIG. 3

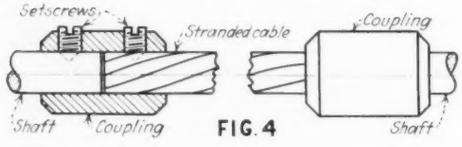


FIG. 4

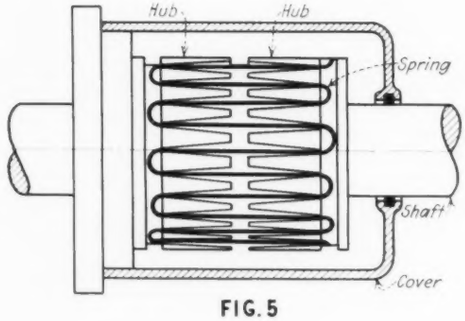


FIG. 5

**Fig. 1**—A rubber hose clamped to two shafts. For applications where the torque is low and slippage unimportant. It is easily assembled and disconnected without disturbing either machine element. Adaptable to changes in longitudinal distance between machines. This coupling absorbs shocks, is not damaged by overloads, does not set up end thrusts, requires no lubrication and compensates for both angular and offset misalignment.

**Fig. 2**—Similar to Fig. 1, but positive drive is assured by bolting hose to shafts. Has same advantages as type in Fig. 1, except there is no overload protection other than the rupture of the hose.

**Fig. 3**—The use of a coiled spring fastened to shafts gives the same action as a hose. Has excellent shock absorbing qualities, but torsional vibrations are possible. Will allow end play in shafts, but sets up end thrust in so doing. Other advantages are same as in types shown in Figs. 1 and 2. Compensates for misalignment in any direction.

**Fig. 4**—A simple and effective coupling for low torques and unidirectional rotation. Stranded cable provides a positive drive with desirable elasticity. Inertia of rotating parts is low. Easily assembled and disconnected without disturbing either shaft. Cable can be encased and length extended to allow for right angle bends such as used on dental drills and speedometer drives. Ends of cable are soldered or bound with wire to prevent unraveling.

**Fig. 5**—A type of Falk coupling that operates on the same principle as design shown in Fig. 6, but has a single flat spring in place of a series of coiled springs. High degree of flexibility obtained by use of tapered slots in hubs. Smooth operation is maintained by inclosing the working parts and packing with grease.

**Fig. 6**—Two flanges and a series of coiled springs give a high degree of flexibility. Used only where the shafts have no free end play. Needs no lubrication, absorbs shocks and provides protec-

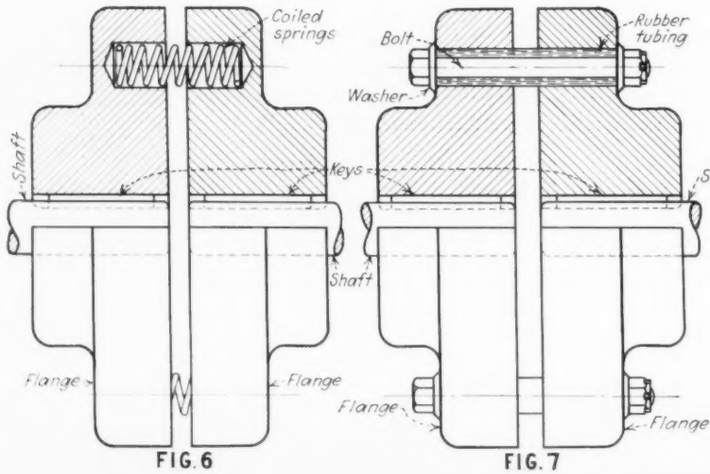


FIG. 6



FIG. 7

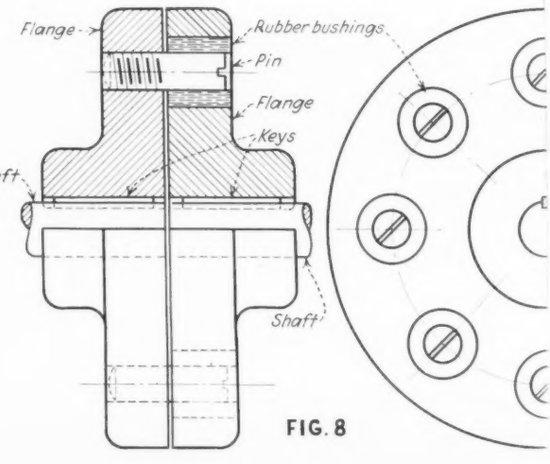


FIG. 8

# *Flexible Couplings—I*

tion against overloads, but will set up torsional vibrations. Springs can be of round or square wire with varying sizes and pitches to allow for any degree of flexibility.

**Fig. 7**—Is similar to Fig. 6, except that rubber tubing, reinforced by bolts, is used instead of coiled springs. Is of sturdier construction but more limited in flexibility. Has no overload protection other than shearing of the bolts. Good anti-vibration properties if thick rubber tubing is used. Can absorb minor shocks. Connection can be quickly disassembled.

**Fig. 8**—A series of pins engage rubber bushings cemented into flange. Coupling is easy to install. Flanges being accurately machined and of identical size makes accurate lining-up with spirit level possible. Will allow minor end play in shafts, and provides a positive drive with good flexibility in all direction.

**Fig. 9**—A Foote Gear Works flexible coupling which has shear pins in a separate set of bushings to provide overload protection. Construction of studs, rubber bushings and self-lubricating bronze bearings is in principle similar to that shown in Fig. 10. Replaceable shear pins are made of softer material than the shear pin bushings.

**Fig. 10**—A design made by the Ajax Flexible Coupling Company. Studs are firmly anchored with nuts and lock washers and bear in self-lubricating bronze bushings spaced alternately in both flanges. Thick rubber bushings cemented in flanges are forced over the bronze bushings. Life of coupling said to be considerably increased because of self-lubricated bushings.

**Fig. 11**—Another Foote Gear Works coupling. Flexibility is obtained by solid conically-shaped pins of metal or fiber. This type of pin is said to provide a positive drive of sturdy construction with flexibility in all directions.

**Fig. 12**—In this Smith & Serrell coupling a high degree of flexibility is obtained by laminated pins built-up of tempered spring steel leaves. Spring leaves secured to holder by keeper pin. Phosphor bronze bearing strips are welded to outer spring leaves and bear in rectangular holes of hardened steel bushings fastened in flange. Pins are free to slide endwise in one flange, but are locked in the other flange by a spring retaining ring. This type is used for severe duty in both marine and land service.

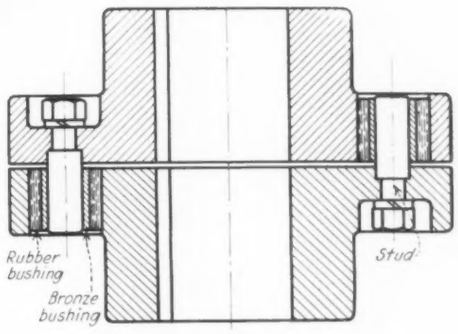
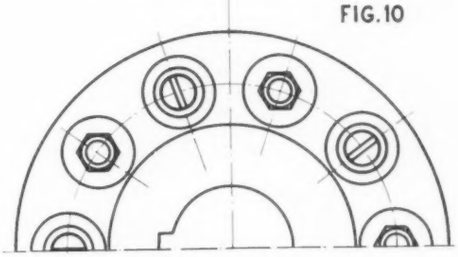


FIG. 10



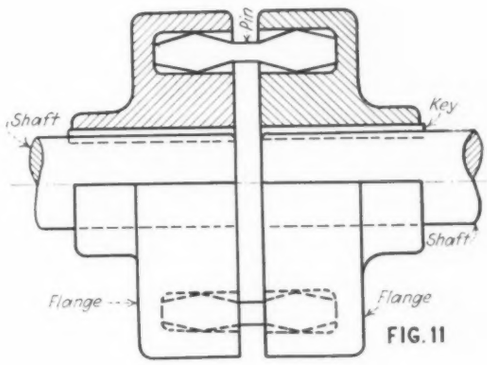


FIG. 11

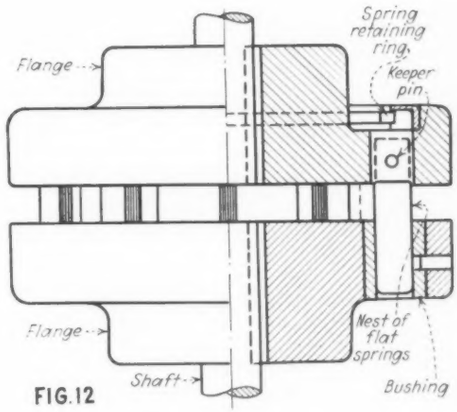


FIG. 12

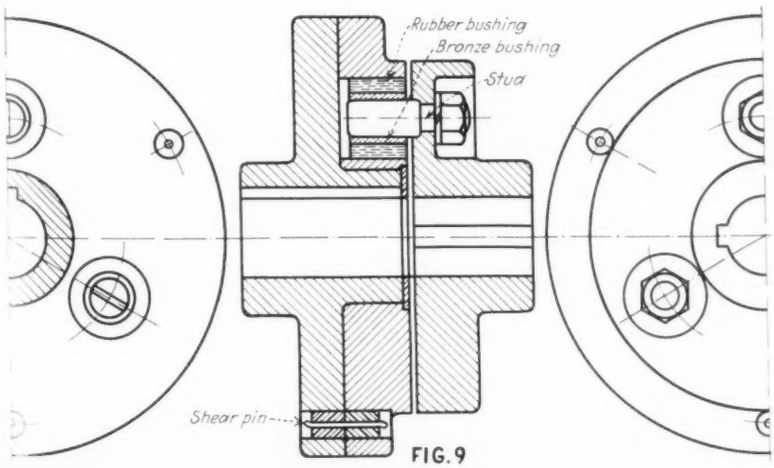
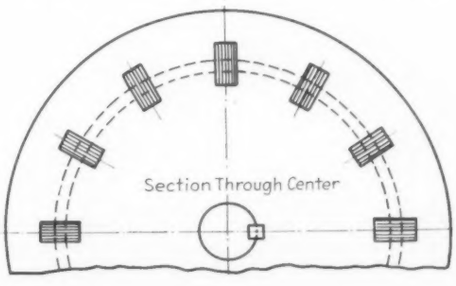


FIG. 9



# NEWS

## *Radical Changes in Patent Procedure Recommended by Advisory Board*

IN THE second report of the Science Advisory Board is contained the results of a study of the present patent system by a committee headed by Dr. V. Bush, vice-president and dean of engineering of the Massachusetts Institute of Technology. Other members of this committee are W. H. Carrier, of the Carrier Engineering Corporation; D. M. Compton, industrial consultant; Frank B. Jewett, vice-president of the American Telephone & Telegraph Company and president of Bell Telephone Laboratories; H. A. Pollin, president of the Research Corporation of New York City, and Maurice Holland, director of the Division of Engineering and Industrial Research of the National Research Council.

According to the report of this committee, there are three primary defects in the present patent system. The first arises by reason of the issuance by the Patent Office of an enormous number of patents, many of which should never have been issued, primarily because of an unduly low standard of invention. The second defect has to do with the excessive cost and delay in the litigations of patents by reason of the present system of appeal. The third defect results from the difficulties met by the court in handling scientific or technical questions without competent and non-partisan assistance.

Three major recommendations are made by this committee. First, the committee recommends that "when an application is ready for allowance, it be published in the Official Gazette and submission of pertinent facts by interested parties invited." This publication should be made in the same manner as employed at present in publishing an abstract and sample claims when a patent is issued. The allowed claims, and preferably also the specifications and drawings, should be open to inspection. All interested parties would be invited to call attention to prior patents or publication on the same invention. If, after an impartial examination of information thus submitted, the application still stands up, the patent would be granted. This method would, in the committee's opinion, eliminate thousands of duplications and the re-patenting of old ideas, speed up motion through the Patent Office, and eliminate a large amount of patent litigation at the source.

A second recommendation has to do with the establishment of a special patents court, with the bench occupied by judges qualified in technology as well as in law, and having a better understanding of the questions before them and hence able to give clearer-cut and more decisive verdicts. It is also recommended that there be provided scientific or technical advisors or juries to furnish adequate scientific or technical assistance in court of first instance in equity patent causes.

The question of compulsory licensing was also considered and the committee recommends that no system of compulsory licensing be introduced at this time.

Other findings of the committee, most of which are of general knowledge, relate to the necessity to increase the standing and ability of the personnel of the Patent Office by providing opportunity for the personnel to make direct contact with industry, the availability to the Patent Office force of better library facilities and consultation with experts on scientific or technical questions.

## *To Celebrate Fiftieth Anniversary*

THE year 1936 is to be a Golden Jubilee year for Westinghouse. It represents the 50th anniversary of the founding of that company by George Westinghouse. Specifically, January 8 represents the 50th anniversary of the granting of the charter to the Westinghouse Electric Company.

In commemoration of its 50th birthday Westinghouse on the night of January 8 will hold a tremendous "family" gathering in Pittsburgh for the 12,000 employees in that district. Simultaneously a similar meeting of Westinghouse employees will be held in every important Westinghouse factory and office in the country. A unique feature will be that the complete Pittsburgh program will be broadcast to all of the other meetings in plants and districts over Westinghouse's own short wave transmitter at W8XK. The program will be sent out simultaneously at two wave lengths, 25.26 and 48.83 meters. It will be picked up in plants and offices all over the United States and also by International representatives and friends in foreign countries. There will be no time limits and the program will probably run from 8 to 10:30 p.m. Eastern Standard Time.

At Pittsburgh the meeting will be addressed by chairman A. W. Robertson, president F. A. Merrick and others including a guest speaker from outside the company. These speakers will review the important contributions that Westinghouse has made to the progress of industry and to the welfare of humanity and present a forecast of the future of the electrical industry.

## *Yardstick Sought to Gage Engineers*

IF a boy is proficient in mathematics in high or preparatory school is he likely to make a success of an engineering course in college? Suppose he is a good speller, or has a good vocabulary, or can write a good letter or report, do those accomplishments have any bearing on the question of whether or not he should take up engineering? These are some of the things that the Committee on Student Selection and Guidance, of the Engineers' Council for Professional Development, is working out.

Preliminary results indicate that the answer to the first question is "yes," which is not entirely surprising. A year ago eight well-known engineering schools, at the committee's request, gave to their incoming freshmen the cooperative test in mathematics as developed by the American Council on Education. At the end of the year the rating of each student in this test was compared with his general scholastic average for the year, and a so-called correlation determined. If this coefficient were as high as 1 it would mean that the test was a perfect indication of what the student would accomplish during the year; if the coefficient were 0 it would mean that the test had no bearing whatever on what he would do in his first year at an engineering college. The general average for 1767 students turned out to be 0.55, indicating that the mathematics test was an excellent indication of freshman accomplishments. Other tests have shown that the correlation between the first year and the other three years of a four-year course is high. If a freshman fails in but one subject he has a good chance to graduate in the regulation four years, but if he has more than one failure his

chance is slim without summer school, private tutoring, or correspondence courses.

Entering freshmen at the same eight engineering colleges were also given a special test in English, which was in three parts covering spelling, vocabulary, and usage. The resulting correlation between the English test score and the first year average for all subjects in the engineering curriculum was about 0.40, or lower than for the mathematics test, but still indicative that a student proficient in the various branches of English is adaptable to engineering work. A less comprehensive study at one engineering college alone, showed that usage ranked far above vocabulary and spelling as an indicator of engineering aptitude. That is, one may be a poor speller and still be likely to succeed as an engineering student, but ability in the use of English is about as necessary as to be proficient in mathematics. In other words, an engineer must be able to organize and express his thoughts in clear, concise English.

## *Papers on Design at S.A.E. Meeting*

MANY papers of special value and interest to product designers will be presented at the annual meeting of the Society of Automotive Engineers to be held January 13 to 17, at Detroit. The titles, authors and time of presentation of some are as follows:

Trends in Automotive Alloys, A. E. White of the University of Michigan, Monday morning.

Customer Research, H. G. Weaver of General Motors Corp., Tuesday morning.

Suspensions, W. R. Griswold, Packard Motor Car Company, Tuesday afternoon.

Cylinder Wear, S. W. Sparrow and T. A. Scherger, Studebaker Corp., Wednesday morning.

Aircraft Engine Probems, Robert Insley, United Aircraft Manufacturing Corporation, Wednesday afternoon.

Metallurgy of Transmission Gears, R. B. Schenck, Buick Motor Company, Wednesday afternoon.

Eliminating Torsional Vibration in the Radial Aircraft Engine, E. S. Taylor, Massachusetts Institute of Technology, Friday morning.

At the annual dinner on Thursday evening, F. M. Zeder, chief engineer of the Chrysler Corporation, will speak on "The Engineer—His Place in Management." At this dinner will also be presented the Daniel Guggenheim medal, the Vincent Bendix trophies, and the Wright and Manly medals.

## *Olen Selected for N.A.M. Speaker*

WALTER A. OLEN, president and general manager of the Four Wheel Drive Auto Company, Clintonville, Wis., has been selected as one of the authorized speakers for the National Association of Manufacturers. This appointment, made at the annual convention of the association held recently at New York City, authorizes Mr. Olen to explain the principles and viewpoints of industry before any and all types of civic and community groups. Through intensive study, long industrial experience and world wide travels he has gained recognition as an authority on the subjects of industrial trends, safety, and co-ordinated transportation.

## *MEETINGS*

**Society of Automotive Engineers**—Annual meeting, Book-Cadillac Hotel, Detroit, Mich., Jan. 13-17. John A. C. Warner, secretary, 29 West 39th St., New York, N. Y.

**American Institute of Electrical Engineers**—Annual meeting, Engineering Societies Bldg., New York, N. Y., Jan. 28-31. H. H. Henline, secretary, 33 West 39th St., New York, N. Y.

**American Institute of Mining & Metallurgical Engineers** — Annual meeting, Institute of Metals Division, Engineering Societies Bldg., New York, N. Y. Feb. 17-21. A. B. Parsons, secretary, 29 West 39th St., New York, N. Y.

### *EXHIBITIONS*

**Motor Boat Show**—Grand Central Palace, New York, N. Y., Jan. 17-25. Ira Hand, manager, 420 Lexington Ave., New York, N. Y.

**American Road Builders Association Exhibit of Equipment**—Municipal Auditorium, Cleveland, Ohio, Jan. 20-24. C. M. Upham, manager, National Press Bldg., Washington, D. C.

**Fourth International Heating & Ventilating Exposition** — International Amphitheatre, Chicago, Ill., Jan. 27-31. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

**Packaging Exposition** — Hotel Pennsylvania, New York, N. Y., March 3-6. American Management Association, 232 Madison Ave., New York, N. Y.

## *New Products Shown at Permanent Exhibit*

AN EXHIBITION of 50 new chemical products, sponsored by the American Chemical Society and known as "The Children of Recovery," is being shown at Metal Products Exhibits—the permanent exhibition of metals, alloys, plastics, and finishes in the International Building, Rockefeller Center, New York. The exhibit is open daily from 10:00 a.m. to 6:00 p.m., and is free to the public.

Each of the chemicals in the exhibit was developed during the past year, and was selected by the American Chemical Society to illustrate the essential role played by research in the world of business as well as in human affairs.

Among the interesting features of the exhibit are the largest single piece of plastic moulding ever attempted, a self-polishing floor wax, transparent paper that is flame-resistant and another variety that is opaque to ultraviolet rays and retards the processes that cause foods to become rancid.

There are also many products of a more technical interest, including several new emulsifiers, bases of synthetic lacquers, abrasives, germicides, and metal coatings.

At the same place is being exhibited steel alloys, the products of 21 different manufacturers.

## *Ferrocolumbium Now Available*

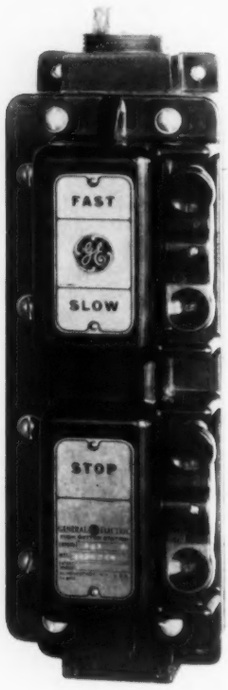
ELECTRO Metallurgical Company, New York, announces that it is prepared to supply ferrocolumbium for the addition of columbium to 18-8 chromium nickel steel. Addition of columbium to stainless steel practically eliminates intergranular corrosion even when the metal is exposed simultaneously to high temperatures and corrosive chemicals. Columbium-bearing stainless steel of the proper carbon and columbium contents may be used between 1000 deg. F. and 1500 deg. F. without developing intergranular corrosion.

Since columbium does not burn out to a harmful degree during welding, columbium-bearing stainless steel welded with a rod of similar composition may be used without subsequent annealing. Weld metal and base metal are equally free from susceptibility to intergranular corrosion. Moreover, columbium does not impair the excellent general corrosion resistance of stainless steel. Ferrocolumbium provides a convenient and economical means of adding columbium to any melt.

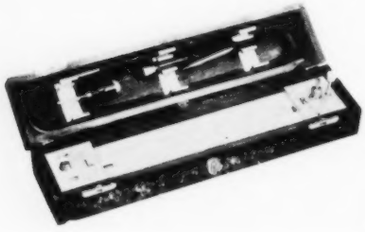
# New Materials and Parts

## *Water-Tight Master Switch*

Is of push-button type, mounted in molded phenolic-compound inclosures for Naval or equivalent industrial applications. Each unit is operated by a molded-compound lever. Four units can be mounted in one inclosure. Either momentary-contact units or a combination of momentary-contact and latched-in units are available. General Electric Co., Schenectady, N. Y.




## *Air Meter*



For direct measurement of duct and passage interior having pressures and vacuums of 0.00125 to 0.5 in. of water, and velocities of 140 to 2,832 ft. per min. A metal tube, inserted in a small hole in the duct, is connected with the graduated scale by a rubber tube. The zero and leveling devices are integral with the instrument. The air meter is self-contained in the wooden carrying case. Julien P. Friez & Sons, Inc., Baltimore, Md.

## *Safety Limit Stop*

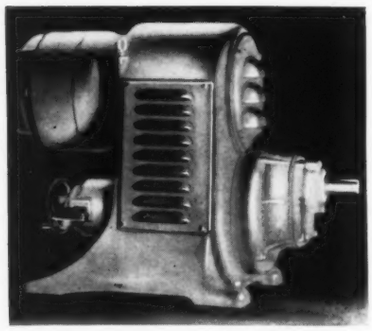
Used for preventing over-hoisting accidents on overhead traveling cranes and other applications where positive protection against overtravel is essential. This "Youngstown" safety limit stop is of the main motor circuit type, using motor current directly without the aid of additional equipment. When the stop is tripped, it disconnects the motor from the power line and is said to bring the motor to rest quickly with minimum drift. Needle-type roller bearings are used for ease of operation. Cover is gasketed, providing splash and dust-proof protection. The Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio.

## *Selfvulc*

For protection against abrasion, corrosion acids and fumes. Can be applied in liquid form, being brushed, sprayed, dipped or poured on. The plastic type is applied with a spatula or any flat tool. Both types are said to vulcanize cold, when exposed to the air. It is claimed to withstand abrasive materials such as coal, ore, sand or metals when used for chutes, flumes, hoppers or bins. Other uses are for all types of containers, fans and impellers, waterproofing canvas and other fabrics, wire insulation, troughs, and sand-blasting cabinets. Also used to prevent breakage where glass, tile or other breakable materials are used. Self-Vulcanizing Rubber Co., Inc., 605 W. Washington Blvd., Chicago, Ill.

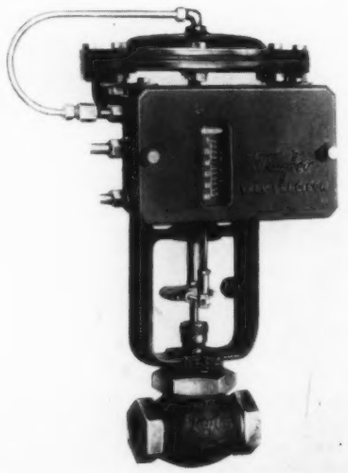
## *Upright Varidrive*

Is used where lateral space for horizontal drive is not available. Take-off shaft can be either in the high or low position. Motor is flange mounted. U.S. Electrical Mfg. Co., 200 E. Slauson Ave., Los Angeles, Calif.



## *Valve-Precisor*

A precision-valve-action unit applicable to any diaphragm valve. It is claimed that the valve-disk of any air-operated controller can be positioned 50 times more accurately with the aid of this device, when opposed by valve-



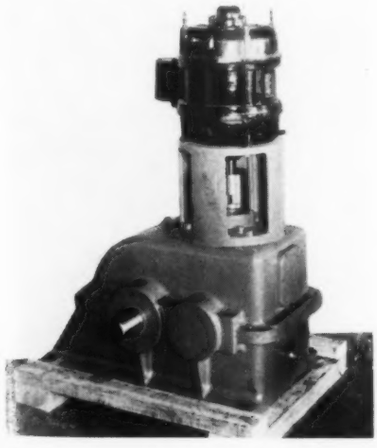
stem friction and diaphragm-motor hysteresis. Can be used on all processes that have time lags or heat capacities requiring low or medium controller sensitivity where the load changes are negligible or infrequent. Case dimensions are 8x5x2 in. deep. Taylor Instrument Companies, Rochester, N. Y.

## *Finish Coatings*

A vehicle made of a combination of pure vegetable gums and heat-treated oils, containing no linseed oil or synthetic resins. It is said to form a film free from porosity and to be impervious to water and corrosive atmospheric gases, also that it will not peel, chip or crack. Material is applicable to wood, concrete and plaster. Mixed with metallic zinc, it is applied to black and galvanized surfaces where salt-water exposure is severe. Requires 25 per cent less aluminum powder than is ordinarily used. Can be applied by brush, spraying or dipping. Can be thinned with turpentine or high-grade mineral spirits. Said to dry in 4 to 16 hours, depending on drying conditions. Technical Coatings, Inc., 9-15 Park Place, New York, N. Y.

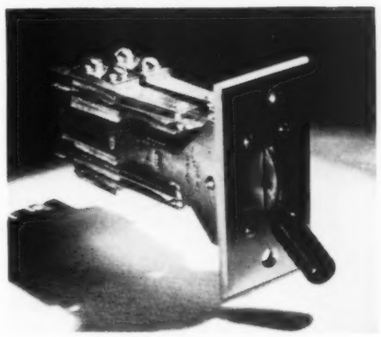
## *Speed Reducer*

Is of the horizontal type with motor vertically mounted on top of the housing to reduce floor space. Reduction is through a combination of spiral bevel gears and continuous tooth herringbone gears. All gear shafts are mounted on Timken roller bearings. Bearings and gears are lubricated by force feed, the oil plunger pump being submerged in the oil inside the housing. Complete range of sizes available from 1 to 200 hp. with reduction ratios of 8 to 1 to 45 to 1 or higher, if required. D. O. James Mfg. Co., 1114 West Monroe St., Chicago, Ill.



## *Temperature and Pressure Controller*

Number 40 controller is applicable for automatic control. It is said that the smallest change of temperature is transmitted positively and with precision to the ball air valve which resets the rate-of-flow through the diaphragm actuated control valve. Both indicating and non-indicating types are available in 9 temperature and 3 pressure ranges. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

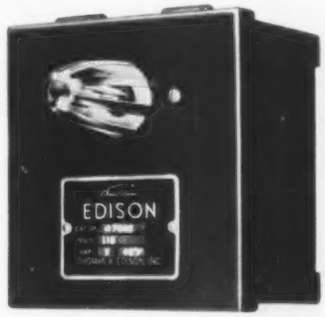


## *Cam Lever Switch*

For use in circuits where the breakdown requirements do not exceed 2,500 volts. The contacts are rated at 1 amp., 110 volts, d.c., non-inductive load. A positive stop is provided in the center position of the handle so the contacts on one side are not affected when the contacts on the opposite side are broken. The contact points are made of silver. A number of contact combinations are available. Two locking or non-locking assemblies can be used on each side of the switch. The Gamewell Co., Newton, Mass.

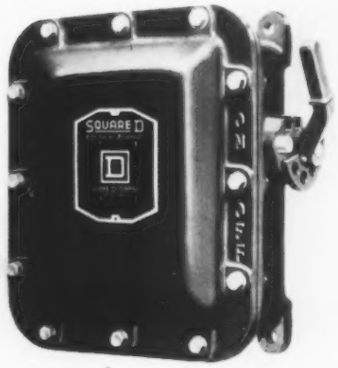
## *Temperature Control*

Is especially adapted for maintaining required temperatures in small inclosures through the regulation of electric space heaters. The contactors are housed in a glass tube and are free from interference from dust, moisture, fumes or other agents detrimental to proper operation. The control is factory calibrated and is said to be tamper-proof. Sealed contact temperature controls are used for electric motor thermal protection, hot stamping and embossing presses, cellophane processing and sealing, wax paper packaging machines, ovens, refrigerators, heaters and other installations requiring temperature control. Thomas A. Edison, Inc., Orange, N. J.




## *Explosion-Proof Switch*

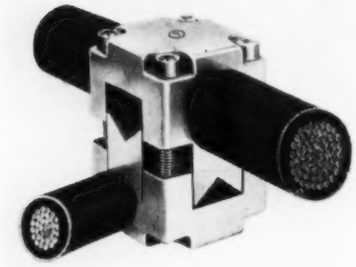
Non-fusible switch for use in hazardous locations. Inclosed in weatherproof case made of cast semi-steel, bolted with corrosionless bolts. Two pipe-threaded conduit holes are in the bottom of the case and pads are supplied on the sides and top for drilling other holes. Provisions are made for padlocking the operating handle in the on or off positions, three padlocks being used in either position when necessary. Single-throw switches are of the quick-make and quick-break type, while the double-throw switches are of the quick-break and positive-make type. Available in 2 and 3-pole, 30 to 200 amp., 575 volts a.c. and 600 volts d.c. capacities. Square D Co., Detroit, Mich.




## *Brake Lining*

Thermoid BX Woven is used for heavy industrial machinery and equipment such as tractors, hoists, shovels and cranes. Made up of a one-ply asbestos tape containing brass wire, the

tape being impregnated with heat-resistant bakelite resin. Material is said to be dense but flexible with 70 per cent asbestos and 30 per cent resin. It is claimed to withstand oil, grease or water to more than 900 deg. F. without deterioration. Thermoid Rubber Co., Trenton, N. J.



## *Electric Cable Connector*

Type P-X-T is for parallel, cross and T-connections. Consists of three reversible pieces with four hollow-head screws for clamping purposes. The top and bottom pieces can be reversed to accommodate a range of wire sizes within the limits of each of the three sizes. Capacities of wire sizes to 1,000,000 C.M. are available. The Trumbull Electric Mfg. Co., Plainville, Conn.

## *Total Time Meter*

Used for totaling running or idle time on electrically operated machine tools, welders, electric signs, refrigerators, radio transmitters or any individual a.c. powered unit. Registers hours during which a circuit is energized or when an apparatus is in operation up to 9,999 hr. before repeating. This meter can be mounted remotely. Inclosed in case with 120 volts, a.c., 60-cycle synchronous motor having jewelled bearings. Case has a flange diameter of 3½ in., and is 3¼ in. high. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

## *Magnetic Chuck Rectifier*

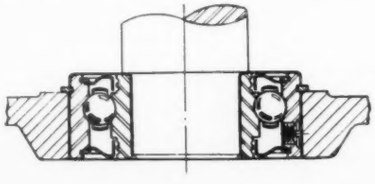
For obtaining rectified a.c. from 110 volt, 60 cycle service. Standard full wave, glass envelope rectifier tubes are used, said to have an average life of 18 months under normal conditions. Built in 4 sizes from 42-120 to 600-1,800 watts and 1 to 15 amp. capacity. Sheet metal cabinet provided with knock-outs for conduit connections and hinged cover. Ward Leonard Electric Co., Mt. Vernon, N. Y.

## *Plastic Molding Material*

Durez 2491 is used for high tension automobile parts that require high dielectric breakdown fatigue values. According to A.S.T.M. tests, this material has a dielectric breakdown of 550 volts per m.m. and a dielectric fatigue of 400 volts per m.m. It is said that when the material is exposed to high tension current leakage, it resists the formation of carbon tracks or arcing channels. Durez 2491 is available in colors of black, brown and red. General Plastics, Inc., North Tonawanda, N. Y.

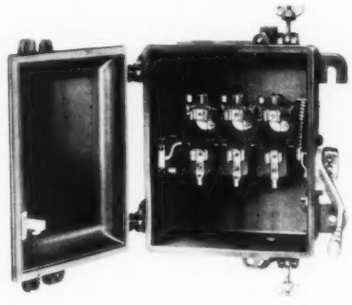
## *Inclosed Precision Ball Bearings*

Completely inclosed single-row bearing of cartridge type is designated as "3000" series. Inner and outer rings are standard double width for large grease capacity. Extra width obviates looseness or "peening" of the shaft and housing because of greater contact area. In most instances the bearing does not require a lock nut. Balls and raceways are protected on both sides by metal seals retained by snap-rings in the outer race. Can be furnished with filling plug for renewal of grease or without filling plug. Made in medium sizes with bores upwards of 25 mm. Also available with or without snap ring on periphery of outer race. The Norma - Hoffmann Bearings Corp., Stamford, Conn.



## *Weatherproof Safety Switch*

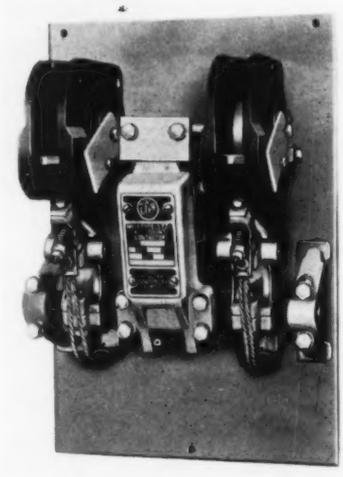
Type A industrial safety switch for quick-make and quick-break contact, is housed in a weatherproof cast-iron cabinet. Said to withstand excessive moisture, rust, lint and corrosive agents. Rubber gasket is used between cover and case. Operating handle has dust-tight bearings and facilities for locking in off-position. Cover has positive interlock for safety of operator. Can



be used in cement, flour, steel and paper mills, breweries, chemical plants, dairies and warehouses where combustible materials are stored. Available fused or non-fused up to 50 hp. rating. Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.

## *Magnetic Contactor*

Is for built-in use. Parts made of aluminum alloy for high-speed operation. Has full-floating armature, resiliently mounted for elimination of



hum and chatter. The full-floating construction is said to give added impetus to the opening of the contactor. Self-lubricating Oilite bearings are made spherical for self-aligning purposes and for ease of panel mounting. Made in a.c. single, double and triple pole of 100, 150 and 300 amp. capacity. Arranged for terminal connections either at front or rear of contactor base. The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.

# MANUFACTURERS' PUBLICATIONS

**Air-operated Controllers** — The Brown Instrument Co., Philadelphia, Pa. Catalog No. 8900, 24 pages, 8x10½ in. Illustrates the construction and adjustment of Air-O-Flow controllers. "Tuning-in" the throttling range, automatic reset and interchangeability of control units are explained.

**Bearings in the Making** — Fafnir Bearing Co., New Britain, Conn. Brochure, 12 pages, 8½x11 in. A photographic review of the major steps in the manufacture of ball bearings. The various operations are explained by concise captions and include cold forming of the balls, forging and machining of the rings, hardening, face, centerless and race grinding, matching and inspection. Eight types of ball bearings in cut-away sections are shown.

**Blueprinting Machine** — Paragon-Revolute Corp., 77 South Ave., Rochester, N. Y. Catalog "Revolute 3E Blueprinting Machine," 16 pages, 8½x11 in. Illustrating and describing the latest model of continuous automatic blueprinting, washing and drying machine.

**Centrifugal Pumps** — Worthington Pump & Machinery Corp., Harrison, N. J. Folder W-321-B-7, 8½x11 in. Open impeller pumps for handling liquids containing solid, gritty or stringy material. Motor flange, supporting pump, is of "Monobloc" construction. For chemical plants, breweries, distilleries, canneries and packing plants.

**Complete Molding Service**—General Electric Co., Plastic Dept., Schenectady, N. Y. Bulletin GEA-2156, 9 pages, 8x10½ in. An explanation with text and pictures of molded plastic technique. The 1,500-ton press, used to make the largest piece ever commercially molded in this country, is shown. Several tables list the physical properties of Textolite molded and laminated and of Cetec cold-molded for various grades of material. Base materials used, colors and finishes obtained, predominant characteristics and general uses are also included.

**Flexible Couplings**—Thomas Flexible Coupling Co., Warren, Pa. Catalog No. 35, 64 pages, 5½x8½ in. Describing non-back-lash couplings using laminated and heat-treated flexible disk rings. A number of styles for various installations are illustrated. General dimension charts and capacities for shaft sizes of 1 to 30 in. diam. are tabulated.

**Leather Packings**—E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa. Four-page folder. "The Plus Value in Vim and Leather Packings." Gives ten reasons why this type of packing should be used and presents ten "Don'ts" for leather packing users.

**Motors** — The Ohio Electric Mfg. Co., 59 Maurice Ave., Cleveland, Ohio. Bulletin 211-A and 212-B, 9 sheets, 8½x11 in. Outline drawings giving dimensions of special designs and identifying them with standard frames. The latter show dimensions of the various types of fractional size motors in standard frames.

**Nickel** — The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Publication, "Use of Nickel Bearing Alloys in Oil Refineries." 4 pages, 8½x11 in. The article describes the wide range of nickel alloy available for use in petroleum refinery equipment. The text points out that because of the extreme temperatures and severe corrosion problems encountered, alloy metals of high physical and mechanical properties must be used.

**Pipes and Tubes** — Republic Steel Corp., Massillon, Ohio. Booklet "The Greatest Pipe Show on Earth." 16 pages, 3½x6 in. Explains types and gives uses of various piping and tubing for all industries. Tubing for mechanical and structural applications and stainless tubing are discussed.

**Potentiometer Controllers for Industrial Temperatures**—The Foxboro Co., Foxboro, Mass. Bulletin No. 202; 20 pages, 8½x11 in. Covers complete line of potentiometer and resistance thermometer controllers including new type H drive unit. Illustrated with photographs and line drawings.

**V-Belt (Texrope) Drives for Machine Tools**—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1259, 32 pages, 8½x11 in. Shows 60 typical applications of V-belts to all kinds of modern machine tools. Single, multiple-belt, multiple-pulley, direct belt drives and idler adjusted drives are shown. Vari-pitch sheaves for belt adjustment are illustrated showing the method of obtaining speed variation.

# BOOKS AND BULLETINS

## *Air-Conditioning for Comfort*

*Samuel R. Lewis.* 277 pages, 5½x8½ in., 79 illustrations, 22 tables. Blue clothboard covers. Published by Keeney Publishing Co., 6 N. Michigan Ave., Chicago, Ill. Price $2.50.

This second edition has been completely rewritten and enlarged since the first edition in 1932. The record sheets for the computation of the heating and cooling loads for residences and commercial buildings are new and have been simplified. Two chapters not included in the first edition explain in detail the design of a year-round air-conditioning system for an office building which includes banking space, offices, stores, restaurant, cocktail lounge and kitchen. All necessary computations are given in their entirety in the explanation of the design procedure. Similarly two rewritten chapters cover the design of a year-round residence air-conditioning system with complete computations, record sheets to simplify the various steps, and necessary tables and charts.

The book contains thirteen chapters, among which terms used in air-conditioning are defined, description of equipment is given and the psychrometric chart and table and its use are explained. Other chapters contain data on formulas and methods of computation, humidifying and dehumidifying, refrigeration, heat transmission, air volume, infiltration and ventilation, air and water circulation and estimating of costs. One chapter discusses air-conditioning and the human body, comfort and health, with data and curves based on the work of the American Society of Heating and Ventilating Engineers.

## *The Book of Stainless Steels*

*Ernest E. Thum.* 813 pages, 6x9 in. Clothboard covers. Published by the American Society for Metals, 7016 Euclid Ave., Cleveland, Ohio. Price $5.

The consumer's standpoint rather than that of the producer is the basic approach to compilation of the material for this book. Now in its second edition, the work presents information on fabrication, properties and utilization of heat and corrosion-resisting alloys of stainless steel and stainless iron. Each chapter is written by a recognized authority in his field.

In rewriting and adding to the first edition, approximately 25 per cent more material appears in this second edition. Twenty-seven chapters are

new or have been rewritten, and corrections have been made throughout the other pages. New material includes a chapter on the arc welding of high chromium irons, also a number of chapters on various types of castings, and an index of alloys produced under tradenames in the United States. The scope, presentation and indexing of this book should commend it to any production executive or engineer likely to encounter the use of stainless steel or iron in his work.

## *Press Work Pressures*

*C. W. Lucas.* 128 pages, 8½x11 in. Profusely illustrated. Blue clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $4.

This first edition will be of interest to the design engineer because of the wealth of data on pressures required for a wide variety of shapes and materials. These data are based on an experience of over twenty years. The presentation is in concise form with illustrations on the left-hand pages and the accompanying text on the right-hand pages. With each of the more than 500 examples is given the material, stock size and thickness, type of operation and pressure required.

The nine chapters cover all types of press work, among which are forming, forging, coining, drawing, riveting, embossing, hook seaming and curling, punching and shearing, hollow and sprue-cutting. A chapter is included on miscellaneous operations, including straightening, broaching and the like. Press and tool designers will find this book invaluable as a reference.

• • •

### *Check Sheet—Introduction of New Consumer Products*

*Department of Commerce—Marketing Research & Service Div.*, Washington, D. C. Market Research Series No. 7, 51 pages, 8x10¾ in. Obtainable from Superintendent of Documents. Price 5 cents.

Because of the failure to answer the basic questions involved in the manufacture and marketing of new products before actual production begins, this procedure in business has been found to be very expensive. The purpose of this "Check Sheet" is no attempt to tell the manufacturer how to escape losses but to present a method for adequately studying every angle before marketing.

Two charts measuring 10x16 in. contain all the basic questions, but because of individual peculiarities of his product, each manufacturer must give consideration to his own special problems. Chart I under the heading of "Marketing" has 9 main sections, these sections being divided into 4 to 20 sub-heads each. The questions in these sections are checked against 17 separate angles or approaches from which each of the questions on the chart must be studied. In general, Chart I contains questions relative to buying habits of the market and firm relation to the market, competition, price policy of manufacturer, sales promotion and distribution, and organization management of sales forces.

Chart II—"Planning and Production," is divided into 8 sections with many subdivisions which are checked against 17 different angles other than those for Chart I. Chart II contains major questions on sources of ideas and major purposes for which new goods are made, factors for design, production, material, service and new capital investment. The relation of the new product to the regularly manufactured line is discussed. A list of government sources of market research material is included.

•

### *Silent Chain Drive Selector*

*Morse Chain Co.*, Ithaca, N. Y. Double-sided sliding chart, 8¼x10¾ in. Cardboard.

This chart is for simplification of silent chain design, making possible the selection of a proper chain drive within the ranges of ½ to 150 hp. Each side of the chart has three windows through which are read all the figures necessary for the average drive. The selector shows the number of sprocket teeth, pitch and width of chain. It gives standard center distances, chain length and diameters of the sprockets and shows what sizes are carried in stock. The chart is adaptable to both high and low driving speeds.

•

### *Speed Control Handbook*

*Reeves Pulley Co.*, Columbus, Ind. 109 pages, 5½x7¾ in. Blue clothboard covers.

Information is given on modern methods of variable-speed regulation for all types of industrial machines. Individual motor, remote and automatic drives are discussed and features of construction are illustrated. Over 75 installation photographs are shown in which variable-speed drives are used for machine tools, baking, confectionery and canning machinery, ceramic and glass, chemical, grain and cereal, packing and textile machinery. Tables of sizes, necessary design formulas and composite dimension diagrams and charts are given. Similar data on Reeves Vari-speed motor pulleys are also included.

•

### *Steel Plates*

*Bethlehem Steel Co.*, Bethlehem, Pa., Catalog 132. Black fabricoid covers, 362 gilt-edge pages, 6½x9 in. Price $1.

The book is fundamentally a reference manual for the design engineer and user of steel plates. All the necessary working data, both engineering and metallurgical specifications, required by the designer or fabricator are contained in this one volume. Under each of the five divisions is correlated all the pertinent data thereto, making it unnecessary to refer to other sources for specific information.

The 122 pages of Part I contain the specifications, tabulated data, and a number of applications of steel plates. The latter includes locomotives, cars, ships, boilers, tanks, stills and pressure vessels and other uses. In Part II, flanged and dished heads with photographs of manufacture, lists of typical shapes and sizes and working pressures are given. Part III relates to tubes while Part IV discusses boiler design, riveted joints and welding.

The 156 pages in Part V are given over to engineering tables all of which are directly applicable to designs using these products. An extensive index of ten pages completes the book.

•

### *Automatic Arc Welding*

*The Lincoln Electric Co., Cleveland, Ohio.* Booklet, No. 5M835, 40 pages, 8½x11 in. Paper covers.

This condensed manual on arc welding is of especial interest to designing engineers because of its treatment of the subject. Welding in the various industries is shown in application photographs and include automobiles, pipes and tubes, steel barrels, drums and large tanks, range boilers, railway coaches, radiator tubes and ships. Physical properties are also included.

•

### *A Visual Report of Progress*

*The New Jersey Zinc Co.*, 160 Front St., New York, N. Y. Booklet, 80 pages, 8½x11 in. Paper covers.

A photographic review of zinc die-casting applications in industry. Over 140 illustrations show many hundreds of different pieces. For automobiles, die-castings from door handles to complete radiator grilles are presented. Gears, cases, roller bearing cages, pump parts and pulleys are among machine parts shown. Small tools, home workshop machines, home appliances and office equipment, business and vending machines, clocks, novelties, toys and locks are among the many illustrations. Properties for four die-casting, "Zamak Alloys" are given in another 42-page booklet, the physical, chemical and thermal characteristics of the metals given in tabular form. The finishing of zinc alloy die-castings is included.

•

### *Bakelite Review*

*Bakelite Corp.*, Bound Brook, N. J. Jubilee edition, Vol. 7, No. 3, 48 pages, 8½x11 in. Paper covers.

Celebrating the 25th anniversary in which "on this occasion it seems fitting to chronicle the history of the company—a history not in terms of brick and mortar, of statistics and charts, but of the human side. This is a story of the building of an idea into a world wide institution—a story of the disappointments, the perseverance, and the achievements of the people, from the very inception of a new industry to the threshold of tomorrow—a story of an organization that, in the short span of 25 years, has not only traversed practically every highway and byway of commerce, but has laid a foundation for a new and essential industry."

One chapter is devoted to "Bakelite Materials in Industry" embracing industries such as radio, textile, automotive, aviation, electrical, abrasive, telephone, packaging and closure, furniture and building and paint and varnish. Another chapter discusses dental work, jewelry, fabrics, glues and bonding agents.